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F. A. WIRT, President **RAYMOND OLNEY, Secretary-Treasurer**

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AGRICULTURAL ENGINEERING

The Journal of Engineering as Applied to Agriculture

RAYMOND OLNEY, Editor

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EDITORIALS

The Program of Research in Mechanical Farm Equipment

THE American Society of Agricultural Engineers has entered into a cooperative movement toward the systematic advancement in research in mechanical farm equipment. The Secretary of Agriculture has appointed a committee of federal, state, and commercial engineers to act in an advisory capacity to his department in the formulation of a program of work in this connection and has provided funds for this purpose. He has also appointed a distinguished member of our Society to direct this enterprise. Obviously, the Secretary could not formulate such a program personally. He has therefore adopted the only logical course—he has provided agricultural enigneers with the machinery and maintenance to build such a program for themselves.

The success or failure of this program of research therefore depends in a large measure upon the cooperation of the entire Society. The implement manufacturing industry is trying to increase the efficiency of farming by providing better farming machinery. It seems quite logical for the state research institutions to find and contribute the facts, which can be transformed into usable and efficient equipment. Since they will, in the long run, carry out the greater part of the work planned, the ultimate success of the program therefore depends specifically upon the intelligent cooperation of the agricultural engineering divisions of the state agricultural colleges and experiment stations. It seems therefore squarely up to the workers in these organizations to do all in their power to make the proposed program one which they can intelligently follow up and carry out.

However, certain obstacles must be met and overcome to do this. It is a fact that the contributions of the agricultural engineering divisions of state institutions to the development of mechanical farm equipment have been relatively small, as compared to those made by the divisions of agronomy, entomology, plant pathology, and others. It is only natural therefore that the experiment station officials consider agricultural engineering as an infant as compared to the divisions of agricultural science. The general impression seems to prevail among them that agricultural engineers are neither very efficient nor very fundamental in their research efforts. In other words, the field of agricultural engineering is not yet a fully accredited one in the experiment stations, and, for this reason, an experiment station director will question the expenditure of a dollar for research in agricultural engineering much more closely than he will that of ten dollars for research in the well-charted fields of agricultural endeavor.

This is considerable of a handicap. It seems to be the fault of the agricultural engineers, however, and not of the directors. The truth is that many agricultural engineers have not as yet fully won their spurs in research at the experiment stations, and all agricultural engineering divisions are therefore handicapped to a greater or less extent by this fact. Only recently the vice-director of one of the larger experiment stations said to a member of the A.S.A.E. Research Committee, "I am impressed with the fact that many opportunities for profitable fundamental research of a widely applicable nature now exist in such subjects as soil dynamics as it affects tillage and traction, soil hydraulics as it affects drainage and irrigation, and in the development of mechanical and structural principles to meet the specific needs of agricultural practices. My greatest difficulty in this connection is to get well-planned projects having definite purpose and direction from our agricultural engineering division."

What the agricultural engineering divisions do with the national program should therefore have a far-reaching effect on this attitude of the station officials, and every member of the Society connected with a state institution will either go up or down in his profession as a result. It is imperative, therefore, that considerable intelligent thought be given this undertaking. And now how can we best proceed?

The Research Committee has come to the conclusion that the proposed program should be made to fit into the research machinery of the experiment stations and has been studying the situation with the idea of making some general suggestions as to how best to do this. In the first place it seems quite evident that a national program should be a composite of the most pressing problems in the different states, united to provide necessary and eliminate unnecessary duplication. In other words, it seems that the value of the program will depend largely upon the extent to which it is specifically applicable to the needs of the individual states. If the workers in the different states confine their contributions to the program to their real problems, those who are actively formulating the program may be able to suggest action, cooperation, and coordination which will have the effect of making the program something of a national unit composed of more or less associated parts. However, the "more or less" is a variable, depending upon the ability and inclination of the individual state engineers to work together.

If there is doubt as to what are the real needs of the agriculture of a state for engineering assistance, an investigation should be made by the agricultural engineering division of the experiment station to establish these needs. It is hardly reasonable to expect the national committee, which is formulating the program, to determine independently the most pressing problems of an individual state without assistance from the people in that state responsible for knowing and meeting the needs of its agriculture. Furthermore, the importance of a problem should be clearly proven by facts before it is included in a national program as a contribution from an individual state, for this point will inevitably arise when funds are sought for its solution.

Each worker must depend upon his own ability to find and solve his part of the program. He must also make it fit into the established research ideals of the stations, and he must "sell" it to his dean or director, if he expects financial support. It is well to know in this connection that all projects in the agricultural experiment stations expending federal funds must be approved by the U.S.D.A. Office of Experiment Stations at Washington. Standards established by the leading experiment station directors and research workers have been set up in the Office of Experiment Stations, and must be met, if federal research funds, such as the Purnell or Adams funds, are to be obtained. Most of the state funds are administered by local authorities who require similar standards in projects. The Office of Experiment Stations, so far as facilities permit, attempts to advise and assist station workers in organizing and planning specific projects or problems of research and in coordinating existing work in the subject so that the greatest benefit to the general public will be obtained. That office is therefore the logical place to go to for assistance in this connection.

There are those who are inclined to ridicule the term "fundamental research." This attitude of mind shows the lack of a clear conception of the field and function of the experiment station system and of its deals. The ideals of

the experiment stations have long since passed the comparative testing stage. Experiment stations have also long since passed the stage of variety testing as an end in itself, and use such procedure largely as a means of determining variable or checking more basic studies. This does not mean that variety tests in themselves are worthless, but no director would expect to get vouchers approved by a federal inspector on a project, the statement of which reads: "We are going to plant forty varieties of oats and see which one yields the most." Experience has shown, in fact, that the so-called "fundanmental investigation" is the only type that has brought material advancement to agriculture. It is the most economical in the long run.

In the farm machinery field there is now even less reason for simple comparative testing than there is with live materials. The manufacturer should, and does, do this himself. The trouble lies mainly in the fact that most of our machines, due to the lack of fundamental information, have been designed by the cut-and-try method. As the Research Committee sees it, the manufacturers are interested in the experiment stations, mainly in the hope that they can secure the information to improve the design of farm machinery without the necessity for following the expensive cut-and-try method.

The problem thus resolves itself into finding the specific agricultural requirements for machines. What factors enter into these requirements? How and how much do these factors vary? Why? How can they be expressed in the form of mechanical principles and definite specificaitons? When given the answer to these questions, the manufacturer has a definite working basis upon which to provide equipment which will accurately meet the requirements of agricultural operations. Sometimes the materials, or facilities, which the manufacturer has to choose from will not meet these requirements. Further research is therefore necessary to make the specifications more practical. In the extreme case the agricultural practice in question must be modified to meet the requirements of the available materials and manufacturing facilities. Either problem is a research job for the agricultural engineer. The importance of so planning a national program of research as to bring about the fullest coordination of the activities of the implement industry and the state research agencies in a joint service to the industry of agriculture in all its local phases seems therefore so evident as to need no argument.

Another point that should be given consideration by tne experiment station worker in agricultural engineering, especially when contributing to a national program, is that each problem of research should be confined to something specific and reasonable as well as fundamentally important. Some projects are so obviously blanket statements, permitting almost anything to be done under them, that they do not receive much consideration by station officials, and certainly cannot contribute much to a national program of properly coordinated activities. For example, a project on "The Relation of Soils to Plowing" means either that the author of the project is ignorant of both the soils and plowing, or that he intends to work the rest of his life on that one project. A project on "Farm Machinery" or "To Study Farm Buildings" is equally inadequate for experiment station purposes and certainly would add but little to a national program.

It is true that a little popularity and publicity sometimes helps. The devotion of a little time to questionnaires, surveys, and any other kind of superficial activity that tends to focus the attention of those providing support for the institution on important specific problems is sometimes justified. However, such activities should not be mistaken for the really important problems in formulating a research program.

The greatest factor in the whole problems is, however, the attitude of the individual research worker. After all is said and done, unless the research worker is willing to follow up painstakingly the program laid out; unless he is willing to take one small part of some tremendous problem confronting agricultural engineers and find out all about this one thing; unless he is willing to work hard and consistently at a problem when the fickle interest of the public is somewhere else; unless he is willing to train himself in this one specialty for the time being at least; unless he will work with others and let others work with him, he had better leave research and research programs alone. If the experiment stations and colleges accept the program of research which is being developed, we as agricultural engineers must therefore prepare now to follow it through according to the standards of these institutions and the specific requirements of the local agriculture of each state. We can look for help in specific problems from the Office of Experiment Stations and for cooperation and moral support from the equipment industry, but the obligation lies squarely on our own shoulders. The Research Committee considers the formulation of a national program of research in farm equipment as a great step forward for agricultural engineering, but it wishes to emphasize the fact that each and every interested agricultural engineer should consider very seriously the individual responsibility it entails.

M. L. NICHOLS

(Prof. Nichols is chairman of the A.S.A.E. Research Committee. He is also professor of agricultural engineering at the Alabama Polytechnic Institute and vice-director of the Alabama Agricultural Experiment Station. The foregoing editorial expresses the attitude of the Research Committee toward the national research program in mechanical farm equipment. It briefly elucidates the experiment station system and sets forth the ideals which must be met in any research program. While pointing out the opportunities which this program of research presents to the agricultural engineer, it strongly emphasizes the responsibilities involved, especially "the individual responsibility it entails." This editorial is a highly important statement on a highly important matter.—Editor)

Better Farm Homes

WE ONCE heard an agricultural engineer tell how he visited a farm reputed to be about the last word in efficiency; it seems that the owner himself was very proud of the high state of efficiency his farm had obtained. As the latest model automobile bearing the owner and agricultural engineer came into view of the farm, the owner proudly pointed out the most modern of buildings and mechanical equipment in operation in the fields. But as they drove into the farm yard the agricultural engineer noticed a thin, obviously over-worked woman rush out of the back door with a pail to a well a hundred yards or more distant, pump a pail of water and carry it back to the house. The agricultural engineer remonstrated with the owner about this most inefficient practice, with the result that the owner immediately provided his wife with a yoke so that she could carry two pails at once instead of one.

If this story were true it would represent an extreme case, though it does illustrate in a way the relative progress that has been made in engineering the farm and in engineering the farm home. Considerable progress has already been made in the direction of developing a truly engineered agriculture, but we need an engineered household as well. And the latter should keep pace with the former.

The agricultural engineer has been an important factor in contributing to agricultural development along engineering lines, including mechanical power, improved labor-saving equipment, properly designed farm structures, drainage, land clearing, irrigation, rural electrification, etc. His field also extends to developing ways and means of saving time and labor in the home by mechanical equipment and thereby making the farm wife's work less of a drudgery and farm life pleasanter.

In line with this and appreciating the need for still more intensive as well as more extensive effort, the American Society of Agricultural Engineers has called a Better Farm Homes Conference. This conference has been planned and will be conducted by the Farm Structures Division of the Society; announcement of it appears on another page of this issue.

The purpose of this conference is to bring together all agencies interested in the better farm homes movement for a better understanding of the problems involved and to discuss ways and means by which continuity of effort and coordination of activities can be developed. Agricultural engineers will appreciate the opportunity which such a conference affords in giving greater impetus to the better farm homes movement. The time is ripe for the agricultural engineer to assume a leading role in the devolopment of better farm homes along engineering lines.

A Balanced Cost Schedule for Tile Trenching*

By H. B. Roe

Mem. A.S.A.E. Associate Professor of Agricultural Engineering, University of Minnesota

THIS schedule—which is built on a man-hour labor unit—is developed from the trenching data on eighteen farm drainage systems put in from 1908 to 1921 under the supervision of members of the drainage staff of the Minnesota Agricultural Experiment Station. The following general facts relative to these farm drainage systems are presented because of their evident bearing on this entire discussion.

Character of digging. The character of digging falls naturally into three classes: easy, average, and hard. Three schedules are presented covering these three classes. Of the eighteen projects only two fall within the first class (easy digging), both of these being in peat; fourteen projects fall within the second class (average digging), almost wholly in mineral soil; and two fall within the third class (hard digging), also in mineral soil.

Easy digging. Under easy digging was included those classes of soil and soil conditions which presented no very serious obstacles to spading and casting—light soils or rather loose texture, free from roots, stumps, loose gravel, stones or boulders, in which the spade settled readily under hand pressure or a slight pressure of the foot—and where soil moisture was present in just sufficient quantity to give such firmness to the soil as to make the trench walls self-sustaining and the spade slice coherent enough for easy casting. This class of digging includes such soils as peat reasonably free from tough fibers, roots, stumps, etc.; light, porous, sandy loams; sandy clays, and the finer damp sands. (For projects under this class see Table Ia.)

Average Digging. Under average digging was included those soils or soil conditions where there was required a considerable, but not excessive, pressure with the foot to settle the spade and a considerable effort to cast, where there were encountered occasional obstacles such as a light shell of frost, possibly requiring the occasional use of the pick, some cobblestones, or a boulder, or stump now and then, or material which, while easily spaded, is difficult to cast because of its weight, but where the spade slice was, in general, sufficiently coherent to make casting tolerable easy, and where caving of trench walls was infrequent. Such conditions are of the most frequent occurrence in ordinary prairie soils such as loams, clays, and clay loams, except after protracted periods of drouth and during those periods of the year when frozen ground must be reckoned with. (For projects under this class see Table Ib.)

Hard Digging. Under hard digging was included all digging conditions not included under easy and average digging; as, for example, such soil moisture or soil texture conditions as cause a fairly constant tendency for the trench walls to cave, looseness, heaviness, or wetness of material that makes casting difficult; soil so hard, either from drouth or on account of its natural character, that spading of it, in the usual manner, is rendered extremely difficult or impossible so that frequent use of the pick or of explosives must be resorted to; heavy sand and gravel; frequent occurrence of cobblestones, boulders, stumps, etc. This class includes ground frozen to a considerable depth, hard pan, cemented gravel, coarse loose sand, heavy gravel, very stony soils of any class whatsoever and soils so hard, from lack of moisture, as to be difficult or impossible to spade in ordinary fashion. (For projects under this class see Table Ic.)

Limiting sizes of tile and depth of trench. The tile used covered sizes from 4-inch to 22-inch and depths of cut varied from 3 feet to slightly under 12 feet. The data on sizes of tile and depths of trench were complete on all projects.

Although the small sizes of tile such as 4, 5, and 6-inch, are very seldom used in trenches that exceed 6 feet in depth and seldom, if ever, in those that exceed 8 feet in depth, and although it is desirable to avoid, as far as reasonably possible, trenches of less depth than 4 feet for sizes of tile from 18 inches up, for the sake of completeness and uniformity of appearance, Tables III, IV, V, VI and the corresponding curves shown on Plates III, IV, V and VI are constructed to cover all depths of trench from 3 feet to 12 feet for all sizes of tile from 4-inch to 24-inch.

The time factor. The data on time spent on each project are believed to be fairly reliable, although quite a portion of the time is estimated. In this respect the projects in each type of digging fall into three classes as follows:

1. Those in which the time record is exact.
2. Those in which part of the time record is exact, and the balance is estimated between exact or approximately exact bounding dates.
3. Those in which the entire time has been estimated as carefully as possible between approximate bounding dates.

It may be well to state, in this connection, that the author was very closely in touch with the two projects that fall in this last class and in tolerably close touch with those that fall in the second class. He is, therefore, probably tolerable well fitted to estimate correctly the time consumed on each of the projects in these two classes.

Of the two projects where the digging was easy, one falls under Class 1 and one under Class 2 as to reliability of time data, this last one constituting about 81 per cent of the total work in easy digging.

*Journal Series Paper No. 580, Department of Agriculture, University of Minnesota. This paper which was presented originally as a part of the 1924 report of the Committee on Drainage of the American Society of Agricultural Engineers, has been completely revised and additional explanations added.

TABLE I a

PROJECT		TILE			WORK UNITS			Total
No.	Location Town, County	Inner Diam. (In.)	Avg. Cut (Ft.)	Total Lin. Ft.	Per Lin. Ft.	Total Per Item	Grand Total per Project	Man Hours Labor
		EASY DIGGING						
1	Coon Creek, Anoka County	6" or under	3.56	12325	6.2	76415.0		
		7"	4.80	700	13.5	9450.0		
		8"	4.20	1250	11.8	14750.0	100615.0	1288
2	Pens, St. Louis County	5"	3.41	4170	5.7	23769.0	23769.0	488
Totals - Easy Digging							124384.0	1776
Work Units per Man Hour - Easy Digging							70.0	

TABLE I c

PROJECT		TILE			WORK UNITS			Total
No.	Location Town, County	Inner Diam. (In.)	Avg. Cut (Ft.)	Total Lin. Ft.	Per Lin. Ft.	Total Per Item	Grand Total per Project	Man Hours Labor
		HARD DIGGING						
1	Osakis, Douglas Co.	6" or under	3.19	5633	5.0	28165.0		
		8"	4.15	2365	11.5	27197.5		
		10"	4.10	1270	13.5	17145.0		
		12"	3.00	400	9.0	3600.0	76107.5	1555
2	Duluth St.Louis Co.	6" or under	3.64	8904	6.3	56095.2		
		8"	4.52	1200	13.8	16560.0		
		10"	4.79	1214	19.4	23351.6		
		12"	4.76	1160	22.0	25520.0	121526.8	3072
Totals - Hard Digging							197634.3	4627
Work Units per Man Hour - Hard Digging							43.0	

Of the two projects under hard digging, one falls under Class 1 and the other under Class 2 as a reliability of time data, the latter constituting only about 38½ per cent of the total hard digging.

Of the remaining fourteen projects, all average digging, eight fall under Class 1, four fall under Class 2, and two fall under Class 3, as to reliability of time data, the two latter classes combined constituting about 63½ per cent of the total average digging.

Reasonable maximum error in estimated time and resultant work units. From his knowledge of the projects the author believes that the approximations under Class 2 will not involve a maximum error in total time on any project to exceed 10 per cent and those under Class 3 not to exceed 15 per cent. Hence it seems probable to him that the error in work units per hour each class of digging will not exceed the following: easy digging, 8 per cent; average digging, 8 per cent; hard digging, 4 per cent.

It therefore also seems probable that the error in time per 100 feet of trench obtained from the tables and diagrams in this report, under each class of digging will not exceed the following: easy digging, 9 per cent; average digging, 9 per cent; hard digging, 4 per cent.

Character of Table I. Table I presents the physical facts of general interest on the different projects involved, as well as some data derived in the process of computing the final schedules, and hereinafter explained.

METHOD OF PROCEDURE

Fixing upon a work unit. In order to secure a schedule based on the fundamental scientific idea of work as expressed in foot-pounds, it was first necessary to determine a work unit readily adaptable to the class of work here involved. As density of material on different jobs would vary widely, it became evident at once that the foot-pound was not a suitable work unit. But if the assumption be allowed that the total material excavated on any given job would be tolerably uniform in texture and density, a volumetric unit, proportional to the foot-pound in any case, would act as a suitable comparative work unit. Hence, the work unit that was adopted was **the lifting of one cubic foot of earth through a vertical distance of one foot**, as this could readily be determined from the date at hand. The number of such units performed in digging a trench of any given depth for any given size of tile and the number of such units constituting a normal hour of work were computed in the manner hereinafter shown in the discussion of Tables II and III. By reference to Plate II, it will readily be seen that the determination of the foregoing values involves the computation of the areas of cross section of trench and spoil bank and of the vertical distance between the centers of gravity of these cross sections.

The comment has been offered that most hand tilers think of a trench in depths of the number of spades rather than the number of feet, everything up to 3 feet being called two

TABLE I b

PROJECT		TILE			WORK UNITS			Total
No.	Location Town, County	Inner Diam. (In.)	Avg. Cut (Ft.)	Total Lin. Ft.	Per Lin. Ft.	Total Per Item	Grand Total per Project	Man Hours Labor
		AVERAGE DIGGING						
1	Zumbra Heights, Carver County	6" or under	3.34	7100	5.5	39050.0		
		7"	3.77	900	8.2	7380.0		
		8"	4.06	800	11.0	8800.0	55230.0	1300
2	Opposite Halstad, Minn. in Traill Co. N.D.	6" or under	2.80	30700	4.4	135080.0		
		15"	6.50	1000	51.7	51700.0		
		16"	6.50	1500	55.0	82500.0		
		18"	6.50	2465	62.3	153569.5	422849.5	8270
3	Near Belle Plaine, Scott Co., but in Carver County	6" or under	4.03	4110	8.0	32880.0		
		8"	4.50	2175	13.6	29580.0	62460.0	910
4	Grand Rapids, Itasca County	6" or under	3.13	21065	4.7	99005.5		
		16"	5.20	2100	35.8	75180.0		
		18"	5.50	2500	44.6	111500.0	285685.5	3330
5	Oakland, Freeborn Co.	6" or under	3.14	17150	4.7	80605.0		
		8"	2.70	1355	5.7	13423.5		
		10"	3.22	1275	8.0	10200.0	104228.5	2030
6	Faribault, Rice County	6" or under	3.31	20813	5.5	114471.5		
		7"	3.55	1190	7.1	8449.0		
		8"	3.90	800	10.0	8000.0		
		10"	4.20	300	14.2	4260.0		
		12"	4.03	2000	15.5	31000.0		
		14"	4.30	200	21.8	4360.0		
		16"	5.00	1500	32.8	49200.0		
		18"	3.20	640	15.7	10048.0	229788.5	4010
7	Fargo, Cass County, N.D.	6" or under	3.29	42657	5.5	234613.5		
		8"	3.34	1040	7.0	7280.0		
		10"	3.30	760	8.4	6384.0		
		12"	3.60	450	12.0	5400.0		
		14"	4.70	1500	26.0	39000.0	292677.5	8180
8	Moorhead, Clay County	6" or under	3.53	43105	6.1	262940.5		
		8"	4.85	2675	15.6	41730.0		
		10"	5.39	2900	24.2	70180.0		
		12"	5.55	6000	30.3	181800.0		
		14"	5.52	200	35.5	7100.0		
		18"	6.11	330	55.0	18150.0		
		22"	4.34	40	35.5	1420.0	583320.5	9880
Totals for Average Digging, - Carried Forward							2036240.0	37910

TABLE I b (Continued)

PROJECT		TILE			WORK UNITS			Total
No.	Location Town, County	Inner Diam. (In.)	Avg. Cut (Ft.)	Total Lin. Ft.	Per Lin. Ft.	Total Per Item	Grand Total per Project	Man Hours Labor
		AVERAGE DIGGING (Continued)						
Totals Brought Forward							2036240.0	37910
9	Glyndon, Clay County	6" or under	2.84	47460	4.4	208824.0		
		7"	3.92	160	8.9	1424.0		
		8"	4.11	1248	11.4	14227.2		
		10"	4.94	1990	20.3	40397.0		
		12"	5.92	542	34.3	18590.6		
		14"	5.21	400	31.8	12720.0		
		15"	5.46	500	36.8	18400.0		
		16"	6.03	1080	47.8	51624.0		
		18"	7.29	270	78.3	21141.0		
		20"	7.12	1542	83.0	127986.0		
		22"	5.37	808	53.4	43147.2	558481.0	9720
10	New Market, Scott County	6" or under	3.54	47731	6.2	295932.2		
		7"	5.41	1750	17.0	29750.0		
		8"	4.93	1150	16.0	18400.0		
		9"	5.19	1300	20.2	26260.0		
		10"	4.74	400	18.7	7480.0		
		12"	4.53	2500	20.0	50000.0		
		14"	5.00	1110	29.7	32967.0		
		15"	3.47	190	15.2	2888.0		
		18"	5.50	35	44.6	1551.0	465228.2	5420
11	Paynesville, Stearns Co.	6" or under	3.91	9113	7.6	69258.8		
		7"	4.05	700	9.5	6650.0		
		8"	3.93	555	10.1	5605.5		
		10"	4.49	1100	16.5	19585.5		
		12"	5.09	2177	25.3	55078.1		
		16"	7.28	1880	68.5	128780.0	284957.9	2360
12	Meadowlands, St.Louis Co.	5"	3.43	3300	5.8	19140.0	19140.0	230
13	St.Paul Ramsey Co.	6" or Under	3.31	3635	5.5	19992.5		
		7"	5.05	450	14.8	6660.0		
		8"	5.05	175	16.8	2940.0	29592.5	540
14	Minneapolis, Hennepin Co.	5"	3.35	1650	5.5	9075.0	9075.0	100
Totals - Average Digging							3402714.6	56280
Work Units per Man Hour - Average Digging							60.0	

spade work; from 3 to 4½ feet, three spade work, and so on, and that where the cost is based on cubage, it does not take this feature into consideration. In this connection, the author sees no reasonable way of securing a convenient work unit based on the depth of trench in spade lengths. It also seems desirable to remember that if such a schedule as that here presented is generally accepted as feasible, it will be used not only by tilers, but by contractors, engineers, and farmers as well. The work unit here developed is based on familiar concepts and, so, easily understood by all. Furthermore, there is nothing to prevent a tiler from using the tables or curves here presented and taking from them the cost data for depths of 3 feet, 4½ feet, 6 feet, etc., instead of consecutive feet, if he so desires. The values thus obtained will still be correct and usable because still based on the established unit of work, that is, the lifting of one cubic foot of earth through a vertical distance of one foot.

GENERAL ASSUMPTIONS

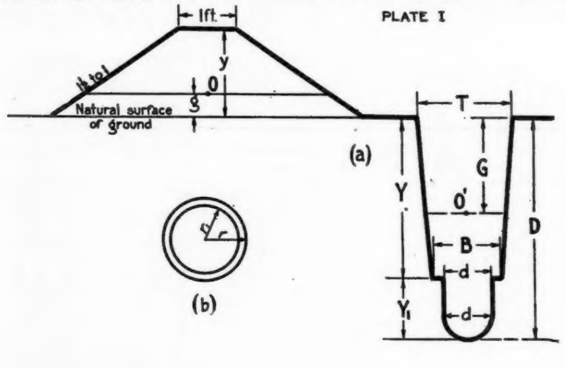
(Refer to Plates I and II, and Table II)

1. A uniform type of trench cross section. For small sizes of tile, it has been our experience that many skillful tilers prefer to save what work they can by digging to a form of cross section approximating that shown in Plate I, leaving a shoulder at the top of the last spading in order to provide width to work in, for which the minimum seems to be about 16 inches, and a working shelf to stand on. However, this shoulder practically disappears with tile 10 inches and upward in diameter, and it was found that the use of such a shoulder caused an awkward non-uniformity in the law of the trenching curve for small sizes of tile as compared with that for the larger sizes. On this account, in the final development of the work unit the shoulder was omitted, and in all cases the sides of the trench were reckoned as a continuous surface upward from the springing line of the semi-circular concave that forms the bottom of the trench, the type of section used throughout being illustrated in Plate II.

2. Batter or side slope of trench walls. Experience has seemed to show that when a narrow trench is being dug, even when it is desired to keep the sides of the trench as nearly vertical as possible, the natural tendency is to give a slight slope or batter to these sides where the soil is firm enough to stand without sheathing. Furthermore, giving a slight batter to the face of an excavation seems to have the effect of increasing the self-sustaining power of such an earth face in soils that are tolerably firm. Some study of this was made at the Minnesota station a number of years ago, under the former head of the drainage work, and the records of this work indicate that tendency and practice seem to give an average batter of about ¾ inch to the foot of depth, or practically 0.06 foot to the foot of depth. Hence a uniform batter of 0.06 foot per foot of depth was used on each wall making a uniform total flare of 0.12 foot per foot of depth reckoning upward from the springing line in each case.

3. Location of springing line. For simplicity in computation the springing line was assumed at the extremities of the horizontal diameter of the basal concave. The theoretical error introduced by this assumption does not involve anything of greater significance than the third place of decimals in the area of trench cross section.

PLATE I



(a) TYPICAL CROSS SECTION OF SPOIL BANK AND TILE TRENCH FOR TILE LESS THAN 10 INCHES IN DIAMETER.
(b) TYPICAL CROSS SECTION OF TILE WALL.

4. Outside diameters of standard tile. All standard tile was assumed to have an outside diameter equal in tenths of a foot to the number of inches representing its internal diameter; that is, the outside diameter of a 4-inch tile is considered as 0.4 foot, that of an 8-inch tile as 0.8 foot, that of a 12-inch tile as 1.2 feet and so on. This is nearly exact and is systematic.

5. Overwidth of base of trench. The allowance of additional width of trench at the springing line to admit the handling of the tile readily in placing and to allow for irregularities in individual tile was taken uniformly at 15 per cent of the outer diameter of the tile considered.

6. Spoil bank; top width and slopes. The spoil bank was considered to be on level ground and to have an average top width of one foot, and side slopes of 1½ feet horizontal run to 1 foot of vertical rise.

7. Average lift. The average lift was considered as the vertical distance between the center of gravity of the trench cross section and that of the spoil bank cross section. (See "Method of Computation of Tables II and III" in another part of this paper.)

8. Lowering and placing the tile, a work element. Lowering the tile into the trench was considered work of the same general type as excavating the earth, and the vertical height through which the tile was moved was in all cases considered equal to the total depth of the trench.

9. Adjustment of machine and team-hours to man-hours. In computing the total hours of trenching labor on each project wherever the Bennett horse-traction ditcher was used (item 7, average digging, Table Ib), it was found to be the equivalent of about 4.4 average men. Wherever the Buckeye traction ditcher was used (Items 8 and 9, average digging, Table Ib), careful comparison in point of time and amount of work with the other projects in the same class of digging indicated that it was the equivalent of about 8.4 average men on those jobs. The two equivalents above stated were used in reducing all the machine labor to a man-hour basis. Where team labor entered into the trenching work a team without driver was in all cases balanced against a man tiler.

It has been the experience of some, the author included, who have had the opportunity to observe machine work, that trenching machines of the heavy traction type, like the Buckeye for example, seem to be more efficient in deep trenching than in shallow trenching. Strictly speaking, therefore, it is probably incorrect to assume, as has been done in this paper, that trenching machine efficiency is constant regardless of depth of trench. However, for the following reasons, the author does not believe that this assumption will seriously affect the practical value of the schedule as developed:

1. Only a small part of the machine work, included in the data used, involved depths of trench in excess of 6 feet and the greater part of the remainder involved depths under 4 feet, none of which is to be considered as deep trenching.

2. It has been the general observation of the author, not however, backed by specific data, that hand labor, also, is more efficient on trenches from 4 to 6 feet in depth and for sizes of tile from 12-inch upward than it is on shallower work, with smaller sizes of tile.

3. On the general run of farm drainage projects a comparatively small part only of the trenching exceeds 6 feet in depth.

In the construction of any given farm drainage project, therefore, the author feels that the variation of labor efficiency, relative to depth of trench, is fairly consistent throughout, regardless of the method by which the work is done, and that this variation is not sufficient to affect, seriously, the usefulness of the schedule developed in this paper. But owing to relative inactivity in tile drainage in Minnesota since this schedule was worked out, he has had little opportunity to test it out on new work. Hence, his opinion as to its dependability is not based, to any appreciable extent,

upon its application to actual new projects not listed in Table I. One such new project, a small one installed on the experimental farm at Duluth, Minnesota, in the fall of 1924 is however shown at the end of this discussion to illustrate the method of using the schedule.

METHOD OF COMPUTATION OF TABLES II AND III

The ratio of tile material to excavated material. The ratio, s, between the density of the material in tile walls and that of average soil excavated from tile trenches, was obtained by computing the average of a series of air dry weights of standard drain tile, both clay or shale, and concrete, and comparing these with the generally accepted average weight of clay or heavy clay loam soils. These ratios were found to be about as follows:

For clay or shale, about	1.0
For concrete, about	1.25

It was assumed that by far the greater part of the tile eight inches and under in diameter would be clay or shale tile while above eight inches it might stand an equal chance of being either clay, shale or concrete, so for eight-inch tile or less the ratio, s, was taken as 1.0 and for all other sizes as 1.125, or $1\frac{1}{8}$.

Areas and distances. The area of cross section of the standard tile sizes, the area of the trench cross section and of the spoil bank cross section, as well as the location, in vertical axis of their centers of gravity and the vertical lift between them, were all computed by standard geometrical and algebraic methods.

Table II is presented as merely illustrative of ten such tables that it was necessary to compute, one for each size of tile as follows: 4, 5, and 6; 8; 10; 12; 14; 16; 18; 20; 22; and 24-inch. The meaning of the various values shown in Table II and the methods by which they were computed are shown in the following lists of symbols and formulas:

It was found inadvisable to compute such tables for 7, 9 and 15-inch tile, as it brought the curves in Plates III, IV, V, and VI so close as to be wholly confusing.

Explanation of symbols shown on Plates I and II and used in Table II. (All dimensions are in linear feet and all areas in square feet.)

On Plates I and II and Table II.

- **D,** total depth of trench
- **T,** width of trench at top
- **d,** diameter of semi-circular concave forming base of trench
- **Y,** vertical depth of trench from top: to base of battered slopes, Plate I; to springing line, Plate II
- **Y_1,** vertical depth of trench from base of battered slopes to bottom trench, Plate I; springing line to bottom trench (d÷2, or radius of semi-circular concave), Plate II
- **O^1,** center of gravity of trench cross section
- **G,** vertical distance, surface of ground to center of gravity of trench cross section
- 1 ft. assumed as constant width of top of spoil bank
- **y,** vertical height of spoil bank
- **O,** center of gravity of spoil bank cross section
- **g,** vertical distance from base of spoil bank to center of gravity of spoil bank cross section

On Plate I only.

- **B,** width of trench at base of battered side slopes

In Table II only.

- **A,** area of cross section of trench or of spoil bank
- **a,** area of cross section of tile wall
- **r,** outer radius of tile
- **r_1,** inner radius of tile
- **s,** ratio of density of material in tile wall to density of ordinary excavated material
- $0.12=(T\text{-}d)\div y$, assumed constant rate of spread of trench cross section from springing line to top
- **π,** ratio of circumference of a circle to its diameter (=3.1416 approx.)

Statement of Formulas used in computing Table II from Plate II.

$$d = 115 \text{ per cent of outer diameter of tile} = 1.15 \times 2r \qquad (1)$$

$$Y = D - \frac{d}{2} = D - Y_1 \qquad (2)$$

$$T = d + 0.12\ Y \qquad (3)$$

$$A = \frac{\pi\ d^2}{8} + \frac{(d+T)Y}{2} = \tfrac{1}{2}\left[\pi Y_1^2 + (d+T)Y\right] \qquad (4)$$

$$= (2T - 0.12\ G)\ G = 2TG - 0.12\ G^2 \qquad (5)$$

$$= \frac{(2+3y)y}{2} = y + \frac{3y^2}{2} \qquad (6)$$

$$= [2(1+3y) - 3g]\ g = 2\ (1+3y)g - 3g^2 \qquad (7)$$

$$\text{From (5), } G = \frac{T - \sqrt{T^2 - 0.12\ A}}{0.12} \qquad (8)$$

$$\text{From (6), } y = \frac{-1 + \sqrt{1+6A}}{3} \qquad (9)$$

$$\text{From (7), } g = \frac{1+3y - \sqrt{(1+3y)^2 - 3A}}{3} \qquad (10)$$

$$a = \pi(r^2 - r_1^2) = \pi(r - r_1)\ (r + r_1) \qquad (11)$$

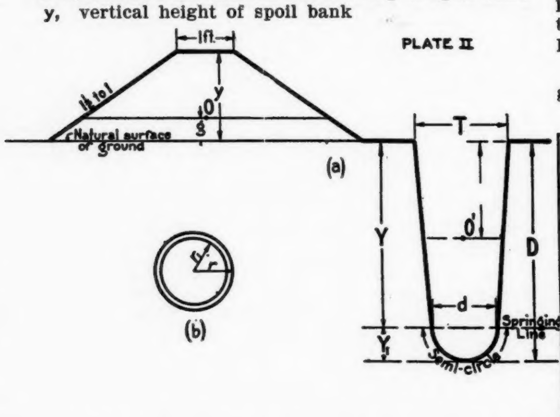
Work units per linear foot of trench due to lowering tile into trench=asD (12)

Work units per linear foot of trench due to excavating trench=A(g+G) (13)

Total work units per linear foot of trench =A(g+G)+asD (14)

Table III gives the values of the quantity A(g+G)+asD for all sizes of tile from 4-inch to 24-inch and for all depths of trench from 3 to 12 feet. This table is simply a compilation of the data in the last column on the right in all the ten tables above mentioned, like Table II and of which Table II is one.

Plate III is plotted from the data of Table III. The values given in Table III are used in the computation of the final



(a) TYPICAL CROSS SECTION OF SPOIL BANK AND TILE TRENCH FOR TILE 10 INCHES IN DIAMETER AND LARGER.
(b) TYPICAL CROSS SECTION OF TILE WALL.

TABLE II
SHOWING FACTORS ENTERING INTO COMPUTATION OF WORK UNITS PER LINEAR FOOT OF TRENCH
Kind of Tile,- Clay or Concrete - Size of Tile,- 10-inch.

D	T	d	Y	Y_1	A	y	g	G	g+G	A(g+G)	a	s	as	asD	Work Units per Lin. Ft. A(g+G)+asD
3	1.44	1.15	2.425	0.575	3.66	1.26	0.44	1.35	1.79	6.55	0.24	$1\frac{1}{8}$	0.27	0.81	7.36
4	1.56	---	3.425	----	5.16	1.55	0.53	1.77	2.30	11.87	----	--	---	1.08	12.95
5	1.68	----	4.425	----	6.78	1.82	0.62	2.19	2.81	19.05	---	--	----	1.35	20.40
6	1.80	----	5.425	-----	8.52	2.07	0.68	2.59	3.27	27.86	----	--	----	1.62	29.48
7	1.92	----	6.425	-----	10.38	2.32	0.76	2.98	3.74	38.82	---	--	----	1.89	40.71
8	2.04	---	7.425	---	12.36	2.56	0.84	3.36	4.20	51.91	----	--	---	2.16	54.07
9	2.16	---	8.425	---	14.46	2.79	0.90	3.74	4.64	67.09	---	--	---	2.43	69.52
10	2.28	---	9.425	----	16.68	3.02	0.97	4.10	5.07	84.56	---	--	---	2.70	87.26
11	2.40	---	10.425	---	19.02	3.24	1.03	4.45	5.48	104.23	---	--	---	2.97	107.20
12	2.52	1.15	11.425	0.575	21.48	3.47	1.11	4.82	5.93	127.38	0.24	$1\frac{1}{8}$	0.27	3.24	130.62

schedules, Tables IV, V, and VI, as later shown under discussion of "Method of Computation of Final Schedules."

Computation of total work units. The items in Table I in the column headed "Work units per linear foot" were read from Plate III according to the average cut recorded in Table I for each size of tile. The product of each of these values from Plate III and the corresponding linear feet of tile of the given size gives the total number of standard work units for that item of the job. All such products are shown in the column in Table I headed "Work Units, Total per Item."

METHOD OF COMPUTATION OF FINAL SCHEDULES (Tables IV, V and VI)

Hour-labor coefficients (Work units per man-hour). Dividing the grand total standard work units in any class of trenching, as given in Table I, by the grand total hours of trenching labor, as given in the same table gave the number of work units constituting an average hour of man labor in that type of digging. As shown under the several types in Table I, these are as follows:

For easy digging	70
For average digging	60
For hard digging	43

Multiplying the successive items of work units per linear foot of trench given in Table III by 100 and dividing these products through in succession by the foregoing hour-labor coefficients for the given class of digging gave the items in Tables IV, V and VI, respectively, for each size of tile and depth of trench. Plates IV, V, and VI were plotted from Tables IV, V and VI, respectively.

DEGREE OF RELIABILITY OF THE SCHEDULES

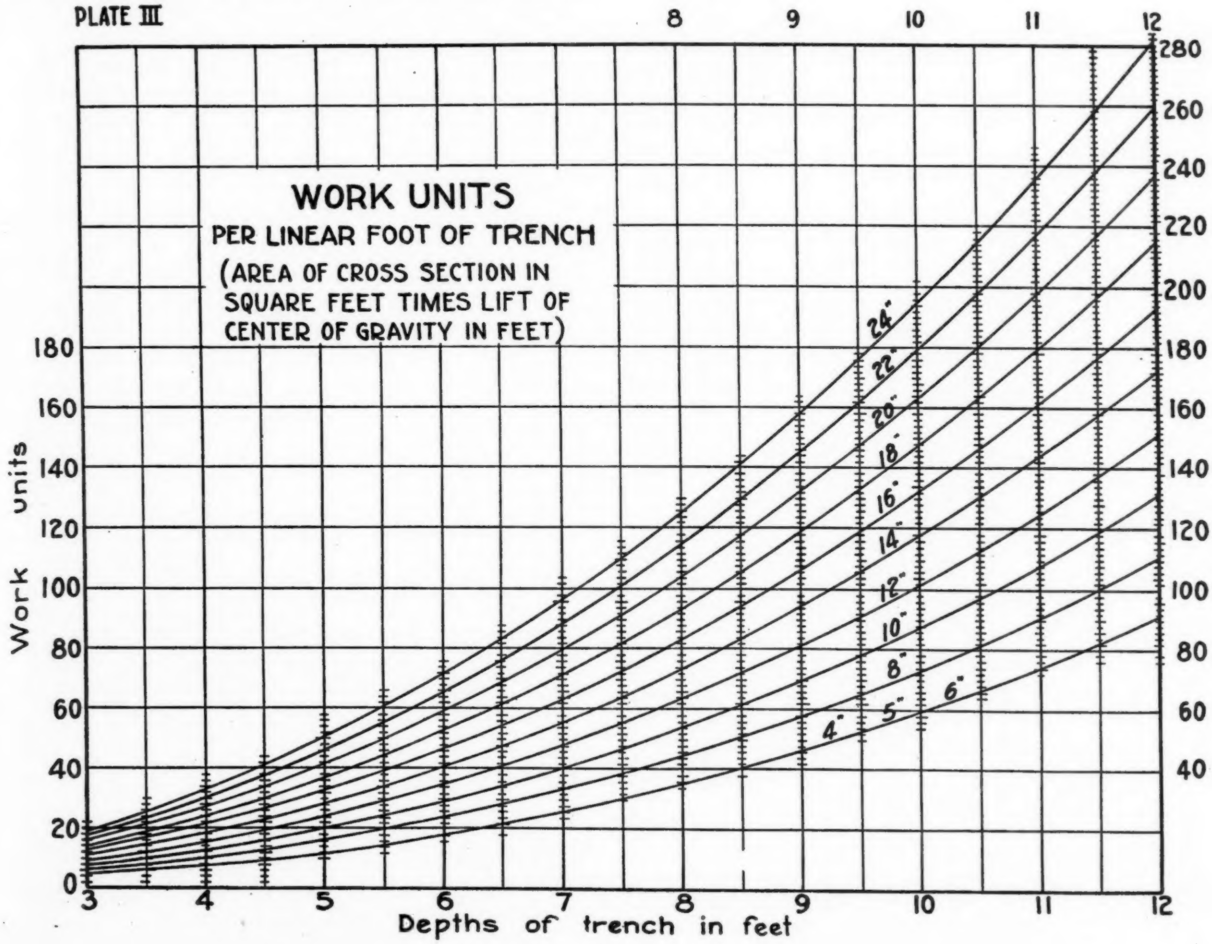
The author does not wish to make any dogmatic claim for the reliability of these schedules. Drainage men generally, the author included, for a long time have been looking for some such tables. Those here offered are open to, and no doubt should receive, severe scrutiny, criticism and improvement. The author will welcome such, but until improvements have been worked out he feels that these will be serviceable and that they will meet, at last temporarily, a long-felt need. It seems evident that they are based on the right principles as they are independent of economic conditions and entirely dependent on the efficiency of labor. Better schedules will appear in the future, but it is believed these will at least point the way.

TABLE III

WORK UNITS PER LINEAR FOOT OF TRENCH FOR SIZES OF TILE FROM 4 TO 24 INCH AND FOR DEPTHS OF TRENCH FROM 3 TO 12 FEET

Dia. Tile	Work Units per Linear Foot for Depths of Trench Shown on Next Line									
	3'	4'	5'	6'	7'	8'	9'	10'	11'	12'
4, 5 & 6"	4.39	7.93	12.72	18.81	26.37	35.60	46.43	59.42	73.80	90.57
8"	5.74	10.47	16.33	24.59	33.52	44.45	57.74	72.85	90.28	109.90
10"	7.36	12.95	20.40	29.48	40.71	54.07	69.52	87.26	107.20	130.62
12"	9.01	15.67	24.16	35.20	48.39	63.68	81.59	101.90	125.84	150.90
14"	10.65	18.58	28.59	41.00	56.08	73.64	93.91	117.00	142.51	172.21
16"	12.37	21.31	32.77	46.91	63.79	83.51	106.21	132.43	160.87	183.29
18"	14.03	24.19	37.09	52.97	71.94	93.31	118.88	147.64	179.31	214.64
20"	15.93	27.19	41.57	59.18	79.99	104.20	132.15	163.21	197.93	237.27
22"	17.75	30.37	46.27	65.57	88.27	115.05	145.16	179.06	217.42	259.18
24"	19.74	33.41	50.82	72.07	97.06	125.59	158.55	195.33	236.24	281.73

PLATE III



The data for Tables IV and VI and Plates IV and VI are too meager for these two schedules to be considered of great value, although they may give a fairly close comparison between the different classes of digging. But Table V and the corresponding Plate V will be seen to be backed by a mass of data which would seem to indicate reliability. The greater mass of digging is probably average digging and schedules from this table should fit closely. Where money values of trenching are wanted, they are also readily computed from the time schedules wherever the value of an hour of labor is known. For example, if, at the given time, common tiling labor is worth 40 cents per hour, and it is desired to know the right price for 100 feet of 6.5 trench for 10-inch tile, for average digging, Plate V shows the hours required to be 58. This multiplied by 40 cents, gives the correct price, or $23.20.

If it is desired to include cost of board or contractor's profit, the bare price of labor per hour should be increased the proper percentage in each case.

It is evident that such a schedule cannot be used to cover cases where unusual difficulties occur or where plank stays or curbing must be placed, but the author still believes that even with these limitations this schedule, where adopted, will gradually lead to more balanced engineers' estimates and contractors' bids.

Some people prefer tables to curves and, by such, Tables IV, V, and VI can be used instead of the curves in Plates IV, V and VI.

TABLE VI

HOURS REQUIRED TO DIG 100 LINEAR FEET OF TRENCH FOR SIZES OF TILE FROM 4-INCH TO 24-INCH, AND FOR DEPTH OF TRENCH FROM 3 FEET TO 12 FEET

(Hard Digging - 43 Work Units per Hour, - Average of 2 Projects Only)

Dia. Tile	Hours per 100 Linear Feet for Depths of Trench Shown on Next Line									
	3'	4'	5'	6'	7'	8'	9'	10'	11'	12'
4.5 & 6"	10.21	18.44	29.58	43.74	61.33	82.79	107.97	138.19	171.63	210.63
8"	13.35	24.35	37.98	57.19	77.95	103.37	134.28	169.42	209.95	255.58
10"	17.12	30.12	47.44	68.56	94.67	125.74	161.67	202.93	249.30	303.76
12"	20.95	36.44	56.19	81.86	112.53	148.09	189.74	236.98	291.26	350.93
14"	24.77	43.21	66.49	95.35	130.42	171.26	218.40	272.09	331.42	400.49
16"	28.77	49.56	76.21	109.09	148.35	194.21	247.00	307.97	374.12	449.51
18"	32.63	56.26	86.26	123.19	167.30	217.00	276.46	343.35	417.00	499.16
20"	37.05	63.23	96.67	137.63	186.02	242.33	307.33	379.56	460.30	551.79
22"	41.28	70.63	107.60	152.49	205.28	267.56	337.58	416.42	505.63	600.42
24"	45.91	77.70	118.86	167.60	225.72	292.07	368.72	454.26	549.40	655.19

Table V

HOURS REQUIRED TO DIG 100 LINEAR FEET OF TRENCH FOR SIZES OF TILE FROM 4-INCH TO 24-INCH, AND FOR DEPTHS OF TRENCH FROM 3 FEET TO 12 FEET

(Average Digging, 60 Work Units per Hour, - Average of 14 Projects)

Dia. Tile	Hours per 100 Linear Feet for Depths of Trench Shown on Next Line									
	3'	4'	5'	6'	7'	8'	9'	10'	11'	12'
4.5 & 6"	7.32	13.22	21.20	31.35	43.95	59.33	77.38	99.03	123.00	150.95
8"	9.57	17.45	27.22	40.98	55.87	74.08	96.23	121.42	150.47	183.17
10"	12.27	21.58	34.00	49.13	67.85	90.12	115.87	145.43	178.67	217.70
12"	15.02	26.12	40.27	58.67	80.65	106.13	135.97	169.67	208.73	251.50
14"	17.75	30.97	47.65	68.33	93.47	122.73	156.52	195.00	237.09	287.04
16"	20.62	35.52	54.62	78.18	106.32	139.18	177.02	220.72	268.12	322.15
18"	23.38	40.32	61.82	88.28	119.90	155.52	198.13	246.07	298.85	357.73
20"	26.55	45.32	69.28	98.63	133.32	173.67	220.25	272.02	329.88	395.45
22"	29.58	50.62	77.12	109.28	147.12	191.75	241.93	298.43	362.37	431.97
24"	32.90	55.68	84.70	120.12	161.77	209.32	264.25	325.50	393.73	469.55

PLATE IV

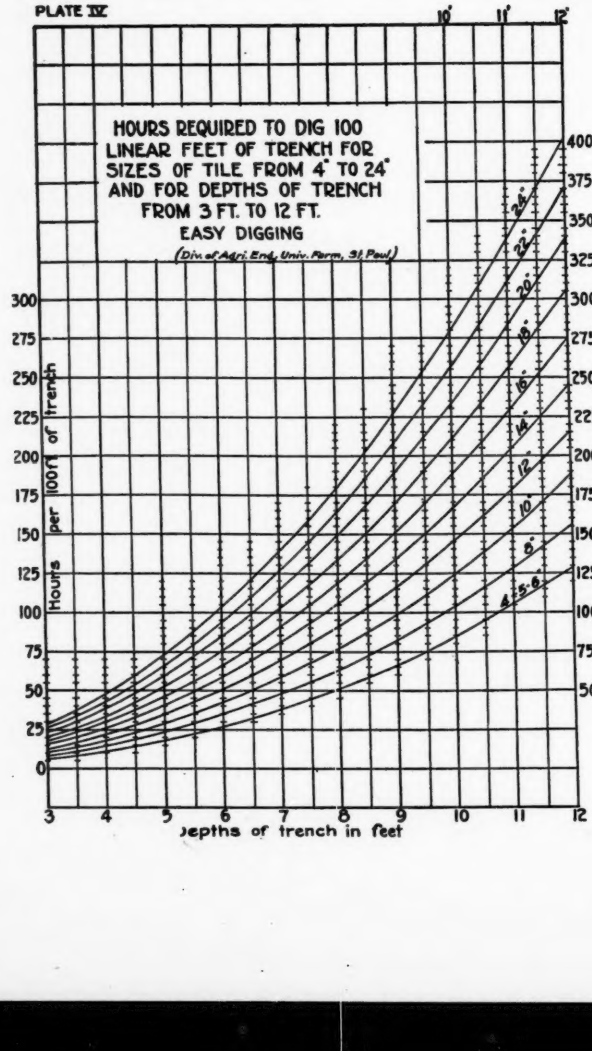


PLATE V

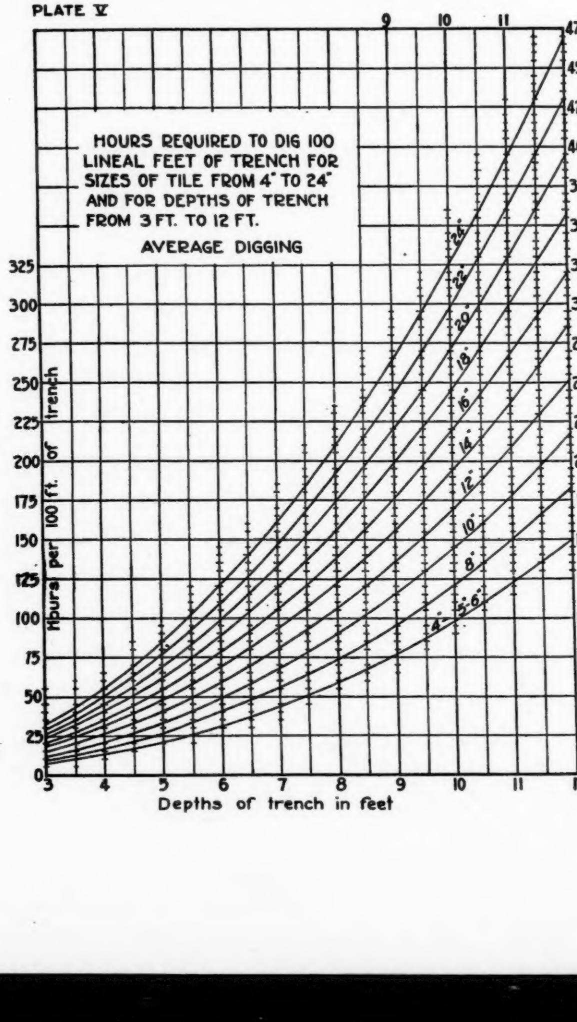


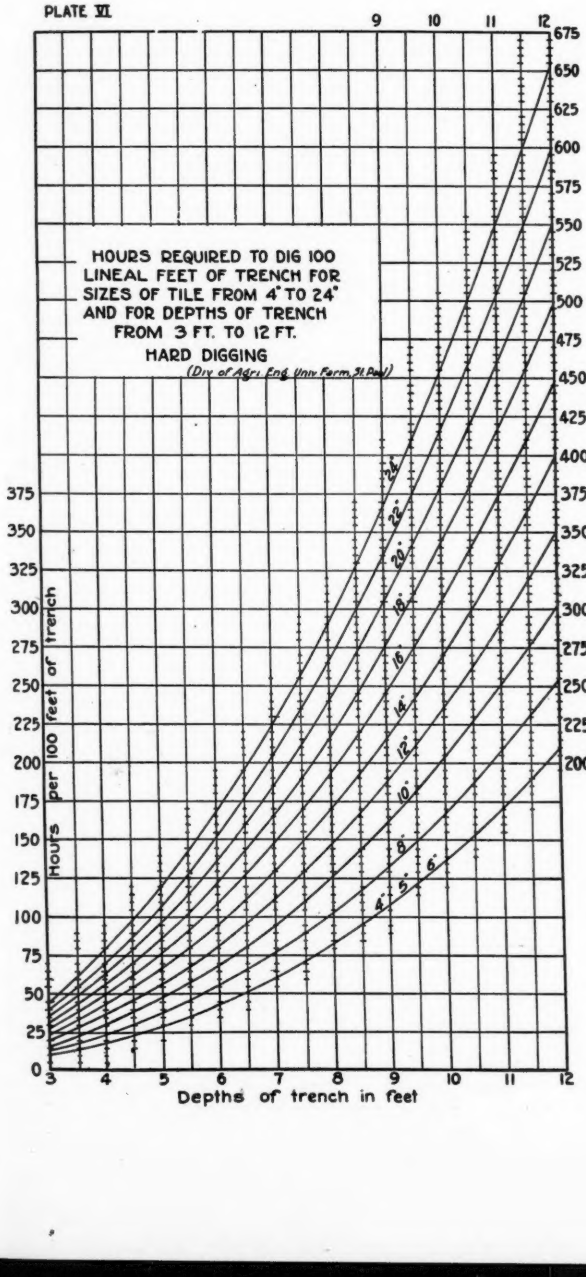
TABLE IV

HOURS REQUIRED TO DIG 100 LINEAR FEET OF TRENCH FOR SIZES OF TILE FROM 4-INCH TO 24-INCH, AND FOR DEPTH OF TRENCH FROM 3 FEET TO 12 FEET

(Easy Digging, - 70 Work Units per Hour, - Average of 2 Projects Only)

Dia. Tile	Hours per 100 Linear Feet for Depths of Trench Shown on Next Line									
	3'	4'	5'	6'	7'	8'	9'	10'	11'	12'
4,5 & 6"	6.27	11.33	18.17	26.87	37.67	50.86	66.33	84.89	105.43	129.39
8"	8.20	14.96	23.33	35.13	47.89	63.50	82.19	104.07	128.97	157.00
10"	10.51	18.50	29.14	42.11	58.16	77.24	99.31	124.66	153.14	187.70
12"	12.87	22.39	34.51	50.29	69.13	90.97	116.56	145.57	178.91	215.57
14"	15.21	26.54	40.84	58.57	80.11	105.20	134.16	167.14	203.59	246.01
16"	17.67	30.44	46.81	67.01	91.13	119.30	151.73	189.19	229.81	276.13
18"	20.04	34.56	52.99	75.67	102.77	133.30	169.83	210.91	256.16	306.63
20"	22.76	38.84	59.39	84.54	114.27	148.86	188.79	233.16	282.76	338.96
22"	25.36	43.39	66.10	93.67	126.10	164.36	207.37	255.80	310.60	370.26
24"	28.20	47.73	72.60	102.96	138.66	179.41	226.50	279.04	337.49	402.47

PLATE VI



PRACTICAL ILLUSTRATION OF USE OF SCHEDULES

The following is an estimate of the time required to do the trenching, laying and blinding of the tile on a small tile drainage system installed by hand on the experimental farm at Duluth, Minnesota, in the fall of 1924.

Explanation of Conditions. Most of this digging was in the hard, stony, clay soil of the Lake Superior region, some was in peat and some was in fair digging in mineral soil. The part of the main constructed of 8 and 12-inch tile was laid in the slope of an existing open ditch, later partly filled, whose bottom was only slightly over a foot above the grade of the tile. Hence, the average cut was materially reduced from that indicated by the levels on the hubs which were on the high side of the tile line, so that most of the excavated material did not have to be lifted the full height of the trench into a high spoil bank, but could simply be rolled over the side into the bottom of the ditch. A careful examination of these conditions and computations based on the existing physical facts showed the reduction from the normal lift to be about 25 per cent. Hence, for the 8 and 12-inch tile the normal time of trenching to the average depth from tops of hubs was taken from the curves and reduced 25 per cent before extending.

Details of estimate. Total Hours

Small open ditch below tile outlet, hard digging, 2098 cubic feet of excavaiton, 1.8 feet average lift; hence, total time equals 2098 times 1.8, or a total of 3776 work units divided by 43 per hour of man labor = 86

Open intercepting ditches at head of system, easy digging, 4722 cubic feet of excavation, 1.1 feet average lift; hence total time equals 4722 times 1.1, or a total of 5194 work units divided by 70 per hour of man labor = 74

Tile

Lin. Ft.	Size Inches	Av. Cuts from hubs, feet	Class of digging	Hours per 100 ft. (from curves)	Adjustment %	Adjusted hours	
600	12	3.00	hard	20	—25	15	90
200	10	under 3.00	hard	16		16	32
1000	8	under 3.00	hard	13	—25	10	100
450	6	4.44	easy	13			59
565	5 & 6	3.00	hard	10			57
250	5	under 3.00	easy	6			15
250	5	3.21	easy	7			17
400	5	3.44	easy	7			28
310	5	3.76	easy	9			28

Total hours for job 586

The total number of hours of man labor actually required on the work 580

Error of estimate (or slightly over 1%) ....+6

Acknowledgments

The author wishes to express his appreciation of the constructive criticisms and helpful suggestions offered by Prof. H. B. Walker, Kansas State Agricultural College, and Prof. E. R. Jones, University of Wisconsin, and of the excellent work done by C. F. Krogh, of the University of Minnesota, who made the drawings.

An unusual opportunity to meet and get acquainted with the recognized leaders of their profession will be given agricultural engineers at Lake Tahoe, Calif., June 23, 24, 25 and 26, 1926, the event being the 20th annual meeting of the American Society of Agricultural Engineers.

Mapping the Dust Concentration Around Small Tractors

By A. H. Hoffman

Mem. A.S.A.E. Division of Agricultural Engineering, College of Agriculture, University of California

DUST entering with the air taken in through the carburetor and causing engine wear was not a serious problem years ago when the gasoline tractors were all big machine with their air intakes seven or eight feet above ground. The amount of dust they took in was exceedingly small even though they worked in the semi-arid regions.

It was a very different matter when the small tractor with low air intake came into use. Large quantities of dust went in. Some cases are on record where the top piston ring in new machines were entirely gone—completely ground out—in fifteen hours' use. A representative of a manufacturer who formerly built a small tractor now off the market recently said to the writer, "Dust and the lack of an efficient air cleaner put our little tractor off the map and lost us a quarter of a million." How much their customers lost was not mentioned.

The agricultural engineering division of the college of agriculture, University of California, at Davis, has devised a simple method of mapping the distribution of dust around a tractor in use, and has tried it out on two tractors.

Strips of bleached muslin were oiled slightly by being dipped into a light lubricating oil diluted with four volumes of high-test gasoline. The excess liquid was squeezed out and the cloths fastened to light wooden frames 2¼ by 2¼ inches by four feet eight inches high. The corner pieces of the frames projected about ⅜ inches beyond the support blocks. Thus the cloth touched the frame only along the corners and at the extreme top and bottom. A black pencil drawn along each corner after the cloths were in place served to mark out the part of each cloth that faced forwards (marked F), rearwards (R), inwards (1), or outwards (0).

Four frames mounted as shown in Figs. 1 and 2 were used in each test. The frames were numbered 1, 2, 3, and 4, at right front, left front, right rear, and left rear, respectively.

The first test made was unsatisfactory because hospital gauze instead of muslin was used and the support blocks of the first set of frames as well as the corners touched the cloth. The wind blew the dust entirely through the cloth where the frames did not touch. This produced results more or less misleading.

The tests were made in a tilled field of fine sandy loam soil. The load was a spring-tooth harrow. In the tests on the Fordson the tractor went twice around a square containing approximately 2½ acres, two rounds being in opposite directions to eliminate differences due to the direction of the wind. The average wind velocity was 9.5 m.p.h. (miles per hour). The tractor speed was 3.6 m.p.h. average and the load was about all the tractor could handle nicely at that speed. Fig. 3 shows the cloths after removal from the frames.

The test on the Cletrac was with the same harrow, run around a similar square in the same field, twice in one direction and twice in the reverse direction. Double distance was run because a slight rain following the tests on the Fordson made the field less dusty. For this reason comparison should not be made between the two dust maps shown in Figs. 3 and 4. The average wind velocity during the test on the

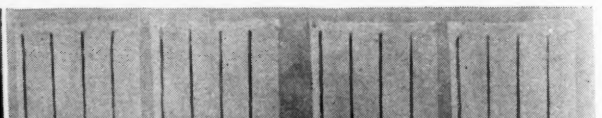
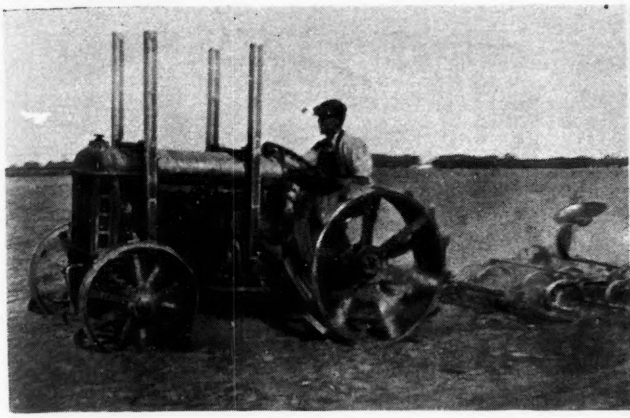


Fig. 3. (Left) Map of dust concentration around Fordson tractor. Frames Nos. 1, 2, 3, and 4 are at right front, left front, right rear, and left rear, respectively. Letters F, R, O, and I refer to the direction towards which that part of the cloth faced and signify, respectively, forwards, rearwards, outwards, and inwards (towards tractor.) Fig. 4. (Right) Map of dust concentration around Cletrac tractor



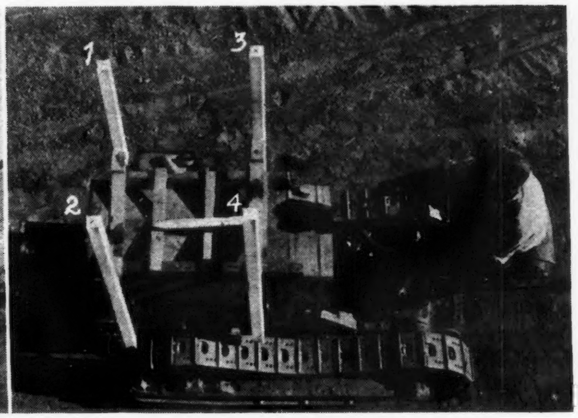


Fig. 1. (Left) Fordson tractor equipped for dust distribution test. White gauze used instead of muslin in this (preliminary) test was found unsatisfactory. Fig. 2. (Right) Cletrac tractor ready for dust distribution test

Cletrac was 4.7 m.p.h. The tractor speed was 3.4 m.p.h. average. The results are shown in Fig. 4.

The charts indicate that in some tractors by proper placing of the air intake of the carburetor the amount of dust contended with may be reduced to perhaps less than one-tenth of what it would normally be in the given machine. This would mean less attention needed by the air cleaner and less rapid choking up if plain filter type cleaners are used.

If a more exact quantitative determination of the relative dustiness at different points around a tractor is desired, a felt filter may be placed between the carburetor and one end of a long flexible tube, the other end of which may be fixed at any desired position on the tractor during a run under given conditions. If proper precautions are taken in drying and weighing the felts and especially if favorable weather may be had so that all the runs in a given series may be made under similar dust conditions, the results may be dependable within about ten per cent. Because of a variety of uncontrollable variables a field test depending upon dust collecting is subject to considerable error. Therefore, such tests should be repeated several times to insure a fair degree of reliability.

Depth of Drains for Reclamation of Irrigated Lands*

By L. T. Jessup

Drainage Engineer, U. S. Department of Agriculture

ONE of the most important problems in the design of drainage systems for reclamation of irrigated lands is the determination of proper depth. On this phase of the subject engineering literature is rather vague, and this perhaps is a reflection of the lack of agreement among those connected with this class of drainage work. In two recent cases before the superior court of Yakima County, Washington, the issue of each depended upon the correct depth at which the water table must be maintained. Several engineers and farmers testified with respect to this point and the divergence of opinion was striking. It varied from two to fifteen feet.

When drainage work first started in the West, the depth was based partly on that used in eastern practice and partly on laboratory experiments as to the height of capillary rise of moisture in soils. Observations on the results of this shallow drainage demonstrated that the capillary rise was greater in many soils than the early experiments indicated and that the slope of the water immediately adjacent to drains was often quite steep.

Laboratory experiments on capillary rise of moisture in soils are helpful, but is it believed that they do not show the maximum height or the rate of rise that occurs in soils in place and in which the structure has not been disturbed. If experiments could be made under field conditions on a variety of soils, they would be of great value.

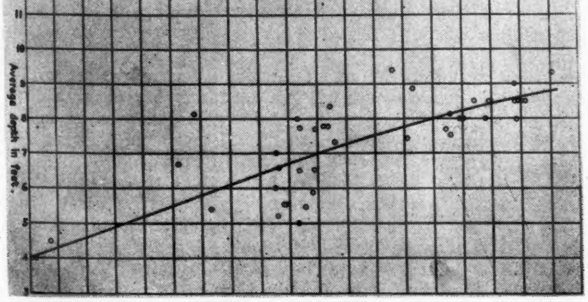
There has been a slow but gradual tendency throughout the West toward deeper drainage. The accompanying graph illustrates this tendency in the Yakima Valley, Washington; it shows the average depth of over forty systems and the date of organization of the districts. Data for the chart were furnished by T. W. Macartney, who has been county drainage engineer since 1918.

The soil is volcanic ash. Subsoils vary somewhat and in places layers of hardpan or sand exist. This makes necessary some difference in depth, but a sufficient number of districts are shown so that average conditions encountered throughout the period are similar. No districts were included which have gravel formations.

It will be seen that early attempts had a depth of four feet. As to reclaiming alkali lands, these early districts were more or less total failures and most of them have since been deepened. During a period of eighteen years the average depth employed has increased over 400 per cent. Perhaps the proper depth has now been attained. It is believed and to be hoped that it has, but this was thought to be the case ten or twelve years ago when the average depth was less than it is now.

There are such a variety of soils and subsoils and of other conditions that it may never be possible to say definitely what the proper depth should be for each combination of the various factors. It is believed, however, that there is a great need for the publication of data pertaining to the many irrigated sections, showing the depth to water table on successful drainage districts with a description of soils and other conditions under which the reclamation was possible.

*One section of the 1924 report of the Committee on the Drainage of Irrigated Lands of the American Society of Agricultural Engineers.



This graph shows the average depth of drainage systems installed in Yakima County, Washington, 1905 to 1923

Equipment for Treating Seed Wheat*

By George W. Kable

Mem. A.S.A.E. Extension Agricultural Engineer, Oregon Agricultural College

THE use of machinery for treating seed wheat has become of importance only in the past few years since the adoption of copper carbonate dust as a fungicide for smut. In the four years since the first experimental work was done with copper carbonate in the United States the popularity of the method has increased until now it is used on perhaps more than sixty per cent of the wheat treated in the Northwest. In Oregon alone the use of copper carbonate for wheat smut is referred to as a million-dollar project.

Stinking smut or bunt of wheat is a disease transmitted by spores. Control of the disease depends quite largely upon killing the spores which may be attached to the surface of the seed.

The commonly accepted methods of treatment for this disease in the past have been sprinkling with or dipping in a solution of copper sulphate or formaldehyde. The disadvantages of the methods are a reduction in germination amounting occasionally to as much as 75 per cent of the seed planted; a retardation of growth with lowered vitality of the plant; the crippling of many of the seedlings; and a possible total loss of the seed, if for any reason planting cannot be done immediately after the grain is treated.

The copper carbonate treatment largely overcomes these difficulties. Treated seed will not deteriorate in storage. Instead of injury to germination, it is now common practice to plant 25 per cent less seed and this usually results in better stands and practically always in more vigorous growth than was formerly obtained.

There are two disadvantages in the use of copper carbonate. One is the toxic effect of the material and the other its possible injury to seeding machinery. In order to avoid headaches and other harmful physical effects, one must keep from inhaling the dust when treating or handling the treated grain. It has also been found that an excess of the dust may cut out the working parts of the grain drill or cause a chemical or electrolytic action between the metal parts resulting in "freezing" and breakage.

The use of copper carbonate as a fungicide for smut is new. It first received attention in Australia in 1915. Tests were started by a number of experiment stations in the United States in 1921. The results to date have been a satisfactory control of the smut disease and a very rapidly increasing use of the method. It is not recommended for the treatment of barley, oats and other grains having hulls.

An accompanying illustration (1) shows a field of wheat at Maupin, Oregon, contrasting the copper carbonate and formaldehyde treatments. The dark strips were formaldehyde treated. The stand was thin and weedy. The lighter strips were copper carbonate treated and the growth was quick and vigorous. The yield was also 50 per cent greater.

In 1923 there were 60 million acres planted to wheat in the United States. The estimated loss due to smut that year was 11,308,000 bushels. A large part of this loss occurred in the four states of California, Oregon, Washington and Idaho, although Kansas reports an average annual loss of $1,000,000. It is noteworthy that the loss attributable to smut is not due solely to the growing of smutted grain. The additional seed used to make up for that injured in the wet treatment and the reduction of yield is probably no less than the loss due to the disease itself.

The application of copper carbonate dust to seed wheat is a mechanical problem. The standard treatment consists in using two ounces of copper carbonate ground to about the fineness of Portland cement to each bushel of seed. The method of application must be such that this small amount of powder will form a uniform coating over every grain of wheat, and be so attached that it will remain there during handling and seeding. Furthermore, because of the toxic effect of the dust, it is highly desirable that it be confined within the treating apparatus, so the operator will not be subjected to the necessity of inhaling it.

On first thought it might seem difficult to keep a dry powder affixed to the coating of the wheat berry. A miscroscopic examination of the berry, however, reveals a roughened surface and a "brush" of hair (2) that would make a bald-headed man envious.

The early forms of treating apparatus consisted of everything from a tight box with a cover in which the wheat and copper carbonate were shaken together, to concrete mixers and a variety of special homemade contrivances.

Heald and Smith of Washington State College published instructions for building a treating machine in Station Bulletins Nos. 168 and 171 in 1922. This was followed in May, 1923, by California Station Bulletin No. 364 by Mackie and Briggs, giving descriptions of the California dusting machine and a patented gravity apparatus invented by Frederick Steigmeyer. Circular No. 107 published by Melchers and Walker of the Kansas Station in 1924 gave plans for two homemade hand-operated machines. In March of this year the Oregon Agricultural College published Extension Bulletin No. 381 giving plans for another type of homemade machine. The first commercial machine to be placed on the market was a continuous duster patented by C. C. Calkins, an Oregon county agent. Two other commercial treating machines are being manufactured in the Northwest: the "Peerless" rotary duster built by the Walla Walla Iron Works, of Walla Walla, Washington, and the "Universal" grain treater put out by the Western Staples Manufacturing Company, of Spokane.

Improvised and Homemade Machines

One of the earliest types of machines used was the ordinary barrel churn. The wheat and fungicide were placed in the machine and turned slowly for several minutes. The resultant treatment was quite satisfactory, but the method was very slow.

The Washington State College machine consists of a drum which revolves on a horizontal axle mounted on a timber frame. Inside of the drum are longitudinal baffle or mixing boards. The drum is rotated by a sprocket and chain drive having a ratio from crankshaft to drum of 1 to 4, the power being furnished by hand. The machine has a capacity of one bag of grain to a batch. The framework and drum are high enough so that the treated grain may be dumped through a hopper into sacks without shoveling.

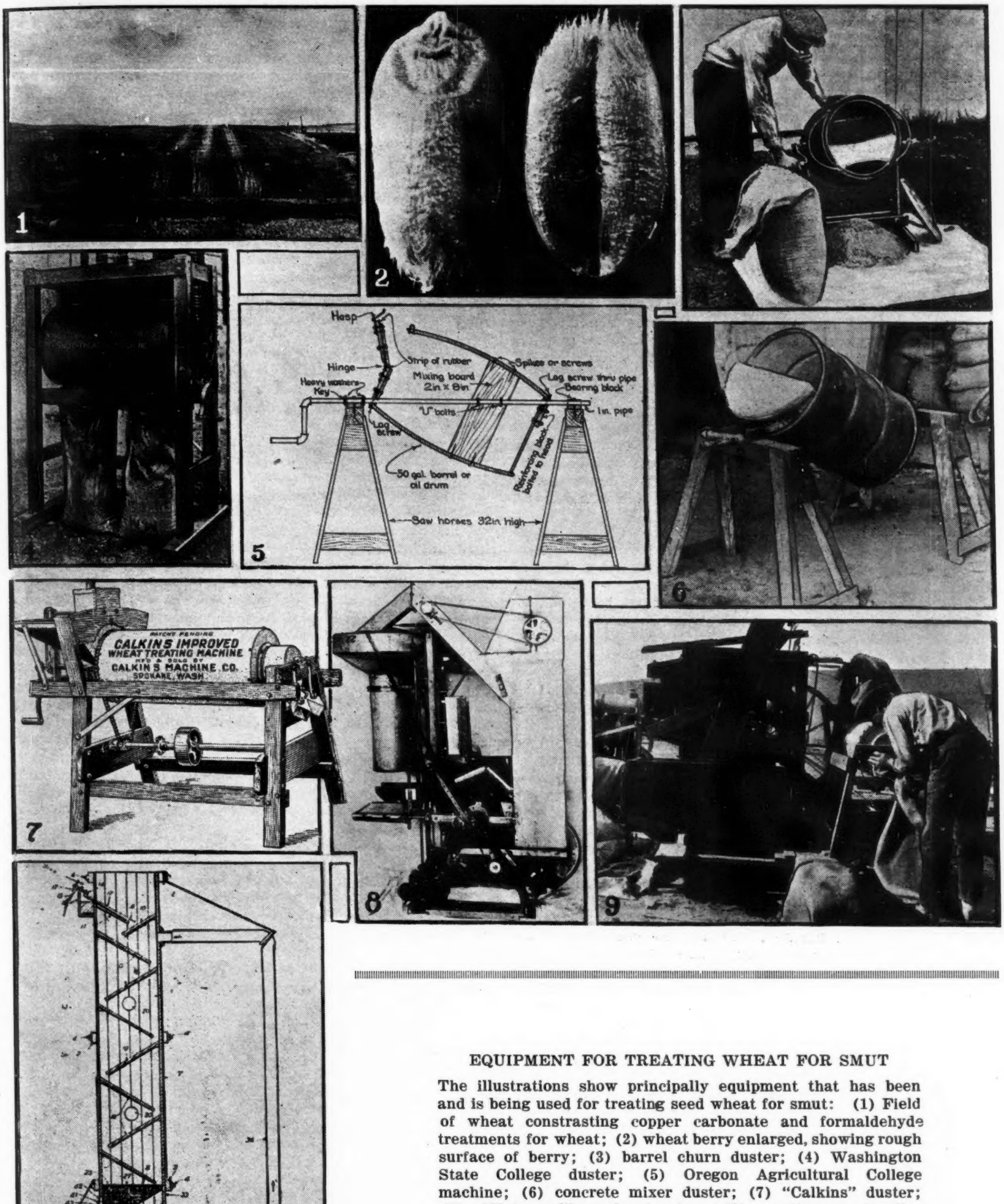
The University of California machine is built very much like the Washington State College duster, the difference being in the substitution of an octagonal wooden drum with a hinged door for the metal cylinder and sliding door of the latter.

Both of these machines turn reasonably easy and do a good job of mixing. They have a capacity of 20 to 30 bushels per hour.

The Kansas station recommends a duster similar to the Washington machine but using an ordinary barrel for a drum and pipe and fittings for axle and crank. This machine has the advantages of being cheaper and more easily built, but considerably more effort is required to turn it.

The diagonal axle machine designed at the Oregon Agricultural College (5) makes use of a barrel or steel drum with a hinged door on the end for a container and standard pipe and fittings for axle and crank. One mixing board is placed diametrically across the barrel about two-thirds of the way back from the door. The machine holds a sack of wheat and has a treating capacity of 20 to 30 bushels per hour.

*Paper presented at the 19th annual meeting of the American Society of Agricultural Engineers, Madison, Wisconsin, June, 1925.



EQUIPMENT FOR TREATING WHEAT FOR SMUT

The illustrations show principally equipment that has been and is being used for treating seed wheat for smut: (1) Field of wheat constrasting copper carbonate and formaldehyde treatments for wheat; (2) wheat berry enlarged, showing rough surface of berry; (3) barrel churn duster; (4) Washington State College duster; (5) Oregon Agricultural College machine; (6) concrete mixer duster; (7) "Calkins" duster; (8) "Universal" grain treater; (9) continuous treating machine; and (10) "Universal" seed conditioner and duster apparatus

When the drum is rotated, the grain is kept constantly in motion resulting in easier turning than where the grain is lifted and dumped from longitudinal baffles.

A series of tests were made on this machine to determine optimum and limiting conditions of operation. In testing for speed of rotation it was found that the mixing action would cease and the grain would be held against the drum by centrifugal force at forty-eight to fifty turns per minute. This maximum speed was not influenced by the amount of grain in the drum. The best speed of operation was found to be about thirty revolutions per minute. When starting a test the wheat was dumped into the machine and the copper carbonate placed in a pile on the surface of the grain. Samples of the grain were taken at each tenth turn and given a microscopic examination. At ten turns, each kernel of wheat was coated, but rather unevenly. At forty turns the coating of dust was complete, smooth and even. Any further turning merely smoothed out and "ironed down" the coating. It is our opinion that the sliding and rolling action of the grain in this type of machine is very effective in giving a quick and even distribution of dust and one which is rolled into contact with the wheat coating sufficiently to remain there.

One other type of improvised duster which has been effective and deserves attention is a small concrete mixer (6) which can be made dust tight by providing a cover for the mixing drum. Such an outfit costs little more than a specific treating machine and possesses the double advantage of doing away with much of the hand labor and being useful for a larger number of days in the year.

Patented Machines

The "Calkins" wheat treating machine (7) is of the continuous type. It consists of a galvanized iron cylinder with cast iron heads and contains two longitudinal baffle plates. Wheat is fed into one end of the drum above the axle by gravity from a hopper. The copper carbonate is forced through adjustable holes in the bottom of a small reservoir above the grain hopper by a rotating agitator or pusher. The outlet end of the drum is contracted compelling the grain to pile up to a depth of three inches before overflowing into the sacking spouts. This arrangement holds the grain in the machine for the length of time necessary for proper treating. The capacities of the three sizes are 30, 18 and 14 bushels per hour and the prices $66, $56 and $40, respectively. This machine is practically dustless in operation except for the dust which comes from the grain as it falls into the sack. An auxiliary dust fan may be added at a cost of $20 to remove the dust from the sacker spouts and from about the sack.

The "Peerless" rotary duster is somewhat similar to the Calkins machine in construction. The revolving drum turns inside of a stationary jacket designed to confine all of the dust. The copper carbonate is fed into the grain hopper by an auger feed regulated by an adjustable friction drive. The machine is built in two sizes. The larger one has a rated capacity of 20 to 150 bushels per hour and sells for $100. The smaller size has a rated capacity of 20 to 60 bushels per hour and the price equipped for either hand or power operation is $65. If it is desired to set either machine low down for ease in filling the hopper, an elevator sacker is furnished at an additional cost of $25.

The "Universal" grain treater (8) is a machine of an entirely different type. It was designed originally for treating grain by the wet process and is described here merely to show the effort which is being made by some manufacturers to develop a treating machine which will dust the grain without dusting the operator. This machine delivers the grain near the floor. It is then picked up and carried by two elevators into a closed sacking hopper. The sacking arrangement is semi-automatic, and similar to those used in flour mills.

An advantage of the continuous treating machines is the possibility of cleaning and treating grain at one operation, the wheat being carried to the dusting apparatus direct from the fanning mill. Such an arrangement is shown in the accompanying illustration (9). The tractor is driving the fanning mill which is connected by chain and sprocket to the shaft of the treating machine. An elevator lifts the grain from a dumping box to the mill and another elevator carries it from the mill to the duster from which it is discharged into sacks.

Central Plant Equipment

Grain treating in central plants is not yet a common practice. The machines which have been described are in use to some extent, and a number of seed dealers and warehousemen have improvised equipment to suit their own conditions. In California a patented gravity mixer is also being used.

One flour mill in Oregon where custom treating is done is using an old flour agitator for the purpose. The agitator consists of a stationary horizontal drum about 2 feet in diameter and 8 feet long with a reel or paddle wheel on the inside which causes the contents to be moved along toward the end of the cylinder while being agitated. Grain is fed into the cylinder from a low bin by means of a bucket elevator. Just before the grain enters the cylinder, the copper carbonate dust is added from a small hopper which has an adjustable feed. The reel or beater in the agitator is run fast enough so that the blades have somewhat of a fanning action which maintains a fog of dust in the machine as the wheat passes through. A microscopic examination of the treated wheat indicates that a reasonably good job is done.

The "Universal" seed conditioner and duster apparatus (10) consists of a vertical wooden stack, 116 inches high and 19 by 36 inches in cross section. On the inside are a series of sloping baffle boards over which the grain tumbles and rolls. The flow of wheat is regulated by a sliding gate in a hopper at the top of the stack. The last baffle at the bottom is made of wire screen and delivers the treated grain to sacking spouts. Copper carbonate dust is blown down through the stack and the excess sucked out at the bottom by a fan driven by a ¾-horsepower motor. A feed hopper in the suction line of the fan supplies the amount of dust required. The outfit is inexpensive to build, conserve and removes the excess dust from the wheat before it is sacked and may be designed to handle almost any quantity of grain.

Until some better method is discovered for controlling smut of wheat the copper carbonate treatment will be widely adopted. The magnitude of the loss attributable to smut each year compells attention to the new treatment. Now that the method is approved and recommended by plant patholigists, its application becomes an agricultural-engineering problem. Apparently there are many types of machines which will make a satisfactory application of the fungicide. Some, however, possess marked advantages over others. A few of the points which merit consideration are:

1. The ability to apply a minimum quantity of copper carbonate dust as a uniform coating to the grain.
2. Making this application with least amount of attendant dust.
3. Removal of the excess fungicide or holding the coating on the wheat so it will not be wasted and will not wear out and otherwise injure seeding machinery.
4. Reduction of the labor and cost of handling grain in treating.
5. Simplicity and low cost of equipment which will make its use feasible.

The problems facing agricultural engineers are so numerous and pressing that they cannot afford to duplicate each others efforts, but rather should they cooperate closely with each other through the national society representing their profession.

How A.S.A.E. Serves Farmer and Manufacturer *

By F. A. Wirt

President, American Society of Agricultural Engineers

THE farm-equipment manufacturers and the American Society of Agricultural Engineers are directly interested from different viewpoints in the same subject, namely, the effective use of improved labor-saving farm machinery. What the agricultural engineers have done, are doing, and will do is, therefore, of deep interest to each and every manufacturer of farm-operating equipment.

Farm operating equipment is directly associated with the labor on the farm of man, horse, and tractor. The tremendous importance of this labor is far greater than is realized........ .... But this large item of labor is the one susceptible of modification and reduction by the application of engineering principles. The items consisting mainly of taxes, interest, insurance, cost of fertilization and other items are not susceptible of the very great modification or reduction. Whether labor amounts to 30 or 60 per cent doesn't matter so much as the outstanding fact that labor is the one big item which can be greatly reduced and must be reduced if we are to have a profitable agriculture.

To this group of manufacturers it is not necessary to say anything about the importance of a prosperous farming population. If the farmer is not making money he is not buying farm machinery, and, in turn, if the farmer is not buying machinery he is not nearly as efficient as he should be. He is building up his costs of power and labor and postponing the day when he can make a profit.

With this problem of farming efficiency the agricultural engineer is deeply concerned. It is a problem that has engaged his attention for years, not from one but from many angles. It is a problem which also engages the attention of the members of the National Association of Farm Equipment Manufacturers.

With this community of interests as a background, I wish to present information regarding the agricultural engineers and their national society, so that the splendid cooperation now existing between the two organizations may become more far-reaching.

In 1907 the American Society of Agricultural Engineers was organized at Madison, Wisconsin. Primarily it was a group of men engaged in the teaching of farm machanics. Agricultural engineering, as such, was not known at that time. But in the eighteen years that have elapsed, the Society has won world-wide recognition for agricultural engineering as a term descriptive of the application of engineering principles of agriculture and as a profession rendering needed service to those engaged in farming.

At the present time the technical activities of the Society are comprehended in five separate divisions: Farm Power and Machinery, Farm Structures, Reclamation, Rural Electric, and College. The N.A.F.E.M. is interested primarily in the work of the Farm Power and Machinery Division and the College Division, but do not overlook the work of the Farm Structures Division in making home life on the farm more enjoyable and of a higher standard of living for all members of the family; nor the Reclamation Division in its efforts to bring about utilization of what in the aggregate amounts to a vast acreage of unproductive land on the farms of this country; nor the newly created Rural Electric Division which will bring together in one influential group the men best acquainted with the light and power needs of the farmer.

The American Society of Agricultural Engineers, in addition to being organized by division of subjects is also organized by geographical location. At the present time, we have the North Atlantic Section, the Pacific Coast Section, and the Southwest Section. Programs of these sections include addresses on farm power and machinery, farm structures, reclamation, electricity, and the problems of teaching, research, and extension. Members of these sections get together for one, two, or more meetings during the year to discuss the problems which pertain to the particular sections of the country in which they live.

The publications of the Society include the A.S.A.E. Transactions and the monthly journal, AGRICULTURAL ENGINEERING. In the Transactions will be found a wealth of information on agricultural-engineering subjects that can with difficulty, if at all, be found elswhere. Authors have shunned the writing of agricultural-engineering textbooks. This most happily does not exist to the same extent today as formerly; slowly but surely we are building up literature on agricultural engineering. But one of the leading sources of information will always be the Transactions of the American Society of Agricultural Engineers. AGRICULTURAL ENGINEERING, the official monthly publication of the Society, is published not for profit but to better carry on the work of the Society. In it will be found interesting articles, committee reports, and a bibliography of current literature on agricultural engineering. Executives, sales managers, advertising managers, designing engineers wanting information on agricultural engineering matters should by all means have ready access to this publication.

A letter from one of the large universities the other day refers to the Journal as the one source of magazine reference when their classes are assigned reading outside of textbooks.

Members of the Society are drawn from the farm equipment and other industries, from the agricultural engineering departments of land-grant institutions, from the U. S. Department of Agriculture, from consulting engineers, from county agents, from Smith-Hughes vocational agricultural teachers, and from miscellaneous sources. Practically all the men engaged in teaching, research, and extension work in agricultural engineering, whether in the employ of a state or the U. S. Department of Agriculture are members of the American Society of Agricultural Engineers. These men are really the consulting engineers for the farmer. They are the men who advise farmers, county agents, and Smith-Hughes teachers of vocational agriculture. These men are really the consulting engineers for the farmer. They are the men who advise farmers, county agents, and Smith-Hughes teachers of vocational agriculture. '

Special mention should be made of those members who come from the manufacturing concerns. Their interest in the affairs of the Society is distinctly beneficial, and is far-reaching. A.S.A.E. members connected with the agricultural colleges and with the U. S. Department of Agriculture appreciate every opportunity to associate with the executive, sales, advertising, production, and engineering representatives of the manufacturers. They are anxious to understand the manufacturers' problems. By contact at meetings and in committee work they obtain a knowledge which is distinctly helpful to them in their own efforts to further the better use of farm machinery. In like manner, representatives of the manufacturers can benefit by contact with each other and with the members of the College Division. It is always helpful to get away from immediate contact with the day's work and talk to others who are interested in largely the same field of endeavor, only from a different point of view.

The application of engineering principles to agriculture from the standpoint of the manufacturer is ever changing. Continual progress is being made. An infinite variety of conditions are encountered in developing a product which will be satisfactory in a country as far reaching as the United States or Canada. Information of real value to the farm-equipment industry can be obtained through the contact of its repre-

*Abstract of an address before the 32nd annual convention of the National Association of Farm Equipment Manufacturers, at Chicago, October 1925.

sentatives, especially the engineers, with the other members of the Society.

You will agree upon the importance of having reasonably complete data before a machine is designed or improved. Much of this needed data and information is readily accessible to the manufacturer's engineers if they are active members of the A.S.A.E. If your engineers are not members of the American Society of Agricultural Engineers, if they are not attending the divisional and annual meetings, conveying their viewpoints to others and receiving information from men engaged in the same profession, they are not serving your best interests.

Some of the reasons why your engineers should belong to the Society have been given. I would like to add one more reason. As manufacturers you build and sell machinery for use in farming, and the American Society of Agricultural Engineers is the only technical organization primarily interested in the successful use of labor-saving farm operating equipment on an ever-increasing scale.

A year ago at this time Mr. E. B. Lourie told you of the work of the joint Committee on Cooperative Relations, a committee made up of members representing the N.A.F.E.M. and a group representing the College Division of the A.S.A.E. He told you of the work accomplished by that highly important committee. He referred to tractor schools for which the committee had outlined a program in detail. He emphasized the plan of inducing agricultural-engineering graduates into the industry and told of certain manufacturers who had already started to employ such graduates, giving them training at the factory and in the field, and then employing them in some capacity in the sales or manufacturing end of the business. He told you of the importance of the Smith-Hughes teacher and his work in teaching vocational agriculture, and how the implement dealer could cooperate with the Smith-Hughes teacher. These activities are being carried on by the agricultural engineers.

You have been informed of the efforts of this committee to bring about greatly needed investigations of many pressing farm machinery problems. This spring a committee representing the A.S.A.E. and the N.A.F.E.M. went to Washington to interview the Secretary of Agriculture. As a result of their efforts, and preceded by a vast amount of missionary work, the U. S. Department of Agriculture will conduct a farm equipment research survey, to be directed by Prof. J. B. Davidson, of Iowa State College. An advisory council representing the N.A.F.E.M., the A.S.A.E. and the U.S.D.A. has been appointed by Secretary Jardine. This council will be of great assistance to the U. S. Department of Agriculture in conducting this important survey. An endless number of problems dealing with the development and application of farm machinery await the investigator. For years the Research Committee of the Society has been doing all in its power to encourage agricultural-engineering research, and we are beginning to witness the result of its efforts.

You will be interested in this connection in the projects carried on at the agricultural experiment stations during the fiscal year 1924-25. By subject classification the projects numbered 6,594, and include the following:

Field crops	1,817	27.6	per cent
Horticulture	1,404	21.2	per cent
Plant pathology	482	7.3	per cent
Entomology	472	7.15	per cent
Soils	343	5.2	per cent
Agricultural economics	235	3.6	per cent
Poultry	205	3.1	per cent
Veterinary	203	3.1	per cent
Dairy cattle	191	2.9	per cent
Agricultural engineering	189	2.87	per cent

Agricultural engineering is last on the list, but it ranks third in the principal increases over the preceding year. The increases number as follows:

Field crops	99
Entomology	50
Agricultural engineering	49

A good many reasons exist for the lack of experimental work in agricultural engineering. No attempt will be made to give all of these reasons, but attention is invited to the fact that the departments teaching crops, horticulture, plant pathology, entomology, soils, and other branches of agriculture receive very strong support from individuals and organizations interested in farming. A great deal of influence is brought to bear and properly so.

The agricultural engineer connected with the college, however, is in a profession which is partly engineering and partly agriculture, and for that reason cannot be thoroughly appreciated either by the old line engineer or by the out and out agriculturist. Here is a real opportunity for the men engaged in the manufacturing of farm machinery to show their interest in the work of the agricultural-engineering departments.

You can use your influence to see that the agricultural engineer receives proper recognition, and this recognition is of greater importance than will occur to you on first thought.

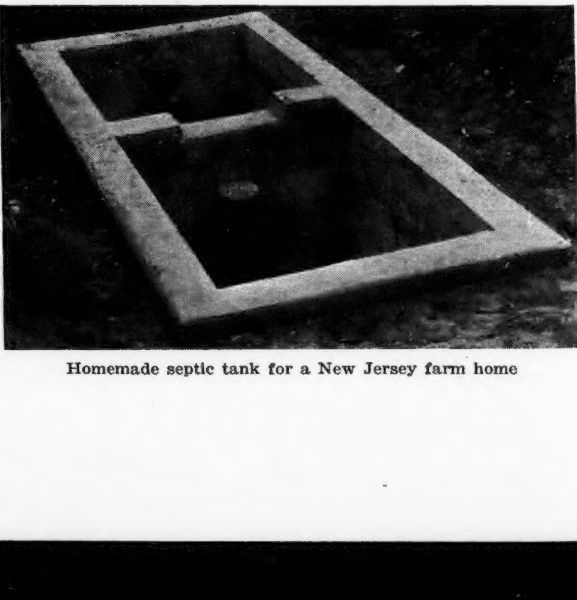
In conclusion, I would call your attention to the spirit of progress and achievement which exists in the American Society of Agricultural Engineers. It doesn't matter whether the members are connected with the manufacturers, with the U. S. Department of Agriculture, with some college or university, or are in consulting work; you will find a spirit that has been likened again and again to that of the Crusaders. How I wish that all of you might have been present at the annual convention held at Madison, Wisconsin, last June. You would have met agricultural engineers from Oregon and California, from New York and Pennsylvania, from Mississippi and Texas, and from Minnesota and Canada. You would have seen a group of men held together by ties of friendship and by mutual interests in a profession which is their life's work. Only those who were present can appreciate the spirit which exists among the members of the American Society of Agricultural Engineers.

The active members without exception have given freely of their time, their money, and their efforts to build up an agricultural-engineering profession and to form a strong national organization of agricultural engineers. From the time the Society was organized in 1907 it has had to fight its way against strong opposition. It has won national—yes, world-wide—recognition for the term "agricultural engineering." They have built a profession of high ideals. They have been a real service to the farmer and to the manufacturer.

Briefly, the American Society of Agricultural Engineers encourages the development and improvement of farm machinery, fosters the more efficient utilization of machinery, and stimulates the increasing use of more and better equipment. With your continued cooperation the Society can be of greater service to your best interests as well as to those of the American farmer.

Engineer Helps Install Septic Tank

TO PROVIDE for laundry, kitchen sink, and bathroom on a 20-acre New Jersey farm some disposal system for the sewage was necessary. With the assistance of the agricultural engineer at the state agricultural college, the ground was laid out for the installation of the tank shown in the accompanying illustration. The complete septic tank, absorption area and plumbing system for the house were all installed with home labor. Running water is supplied by a large pressure tank, gas engine, and pump.—E. R. Gross



Homemade septic tank for a New Jersey farm home

The Opportunities and Requirements for Cooperation*

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AGRICULTURAL engineerng is the connecting link between agriculture and certain manufacturing industries allied to and dependent upon the agricultural industry. The logical development of agricultural engineering should make the individual farmer a greater and more efficient producer, and from his surplus of production he should be able to provide a better standard of living for his family. The agriculturalist is concerned primarily in the production of raw materials for food, shelter, and clothing, but in the operation of his farm business he utilizes manufactured machines and equipment which contributes to efficient and profitable farming. Thus, there is an important relation between these particular industries and the industry engaged in the production of raw materials. These relations are of varying economic importance, depending upon the character and utility of the manufactured product.

Agricultural engineering is concerned chiefly with two general classes of manufactured products: first, those of direct economic value to agriculture in the production, storage and transportation of crops, such as implements, machines, vehicles and building materials; and secondly, those of less direct economic value, but which are no less important in contributing to the comfort, convenience and welfare or rural dwellers. It is the function of agricultural engineering to determine the relation of such manufactured products to the betterment and progress of agriculture, and then use proper educational and commercial methods to introduce such improvements to the farms of this country. To accomplish this task requires more of the agricultural engineer than a knowledge of facts; it requires tact and diplomacy as well. However, it must be recognized that the latter in themselves are of no value unless supported by facts.

The agricultural engineer, first of all, must have a fundamental knowledge of his professional field, but he will succeed more quickly in his work if he is endowed with at least a reasonable amount of tact and diplomacy. He must be absolutely fair in his efforts, frank in his statements, firm in his convictions, honest with himself, able to reach a decision through analysis, and finally he must be aggressive in action. These qualifications will help him gain and hold the confidence of the farmer and the recognition and respect of the producer of manufactured products.

Agricultural engineers are as much interested in the development and success of one of these groups as the other. We will succeed as a profession, when agriculture succeeds. Agriculture will succeed as long as it is able to maintain efficient production in such volume per worker that the surplus produced will insure better standards of living for the farmer. As engineers, we recognize that our present position in the agricultural world, and our present high standards of rural life, have been atttained in no small part through the adoption and use of labor-saving equipment for the farm and in the home. Our future progress depends upon a continuation of these methods.

If we are true to the responsibilities of our profession, we are in duty bound to recognize and work with those groups of industry allied to agriculture which furnish the farmer with labor-saving equipment, better and more permanent building materials, and other accessories and devices which add to the efficiency, attractiveness, and comfort of farm life. Our field of endeavor is clear and relatively well defined. We must lend our efforts to cultivating proper relations between these two fundamental groups, keeping always in mind the ultimate welfare and progress of American agriculture. This is our opportunity.

Cooperation means to work together or jointly with others. This is not as simple a task as the definition seems to indicate. Before individuals or groups are able to cooperate successfully there must be a mutual objective. The results or efforts of attaining the objective may react somewhat differently to the individual cooperators, but these results must be of mutual enjoyment and value. Furthermore, cooperation, to be successful, must be the means of attaining an objective more quickly and with less effort than would otherwise be possible without such united effort.

These requirements are fundamental and should be determined and satisfied before any cooperative enterprise is undertaken. Such conditions in themselves, however, are not insurance of success. In addition, those cooperating must have faith and confidence in one another. Suspicion and distrust breed rebellion, which in itself defeats the very objectives of cooperation. When we, as agricultural engineers, can meet other groups on a common ground with frankness in our statements, honesty in our actions, and with definiteness in our objectives, we are in a position to discuss cooperative relationships.

The College Division of the American Society of Agricultural Engineers is primarily an educational unit. Our big objective is education. Any cooperative relationships we may inaugurate must be founded on this definite objective. The fundamental purpose of education is to stimulate correct thought processes, but if education should stop with mere stimulation of thought it would be worthless. Proper thought must result in definite action so our efforts, while primarily for the purpose of stimulating proper thinking, must take into account resulting action. For example, we may stimulate a farmer to modernize his home, but if no reliable means are available for the installation of dependable plumbing devices our efforts are of little value. Thus, we are interested in a program which extends beyond thought stimulation, but which takes into account action as well.

Our Society has been cooperating with various groups and organization. We have through such efforts directed attention to the induction of agricultural engineers into the implement industry, not for the single purpose of getting jobs for our graduates, but because we believe it will mean a greater use of labor-saving machines on the farm, with resulting greater profit to the farm operator. We are interested in cooperative tractor schools, not for the purpose of giving a college professor a few more days of work, but because we believe proper training in the use of tractors will reduce service expenses for the manufacturer, and make power farming more profitable for the agriculturist. We are interested in cooperative studies in rural electrification not for the purpose of magnifying temporarily the importance of agricultural engineering, but because we realize electrical service will make rural life more satisfying and attractive and through cooperation rural electrical service will become a practical reality much sooner than if we worked independently.

We must have a vision of our opportunities. We must have a knowledge of our responsibilities. We must have self-confidence. We must have faith and confidence in our cooperators. There must be mutual objectives. With these things in mind, I feel we are in a position to discuss cooperative relations and lay plans for further cooperative accomplishments.

*Paper presented at the 19th annual meeting of the American Society of Agricultural Engineers, at Madison, Wis., June, 1925

Research in Agricultural Engineering

A department conducted by the Research Committee of the American Society of Agricultural Engineers

A Method of Research as Applied to a Project on the Air Requirements of Poultry*

By Henry Giese

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IF A problem of research is to reach any desired destination it is not only desirable but also highly essential that a "road map" be consulted and a method of procedure clearly mapped out in advance. While it is not only possible but quite probable that various detours will be necessary from time to time, much unnecessary work can be eliminated and the efforts of other investigators capitalized to the greatest extent, if the project is carefully outined before the work is commenced. This is assuming the desirability of the research in question. De Baufre points out that "research is a necessary evil for any manufacturing concern which desires to remain in business." To this it might be added that the standing of an educational institution is often measured by the amount and quality of its research.

The purpose of this paper is therefore to suggest a method of approach to a problem of research in agricultural engineering and to make a specific application in the case of a project now in progress at the Iowa agricultural experiment station.

General Principles of Approach

Object. In outlining a problem, the first question is very naturally a statement of the object. This is not only essential for the benefit of the reader, but because it often has a very good effect upon the research worker in helping him to get a better grasp upon the subject at hand. The statement of the object should include (a) a statement of the nature of the research, whether it be to develop a new machine process or article of manufacture, or to ascertain the underlying principles to be used in the solution of another problem, and (b) a careful expression of the exact problem.

The plans proposed for accomplishing the desired result should then be briefly stated. The value of cooperation should not be overlooked in this connection. Problems are often quite involved and vary so in nature that no one man has knowledge which is at the same time broad enough and specific enough to see it through. No pains should be spared to secure the benefit of those best posted in each particular line.

History and Starting Point. With the problem clearly and carefully stated and the proper cooperation arranged for, the next step is to make a careful investigation to ascertain what has gone before. There are at least two reasons for doing this. First, a study often shows that the subject has already been thoroughly investigated and further study would be entirely unjustified, or, second, the efforts of others, while not complete or sufficient in themselves, offer valuable suggestions on procedure. One characteristic which is supposed to distinguish man from the lower animals is his ability to profit by the mistakes of others. Some steps may be modified or entirely eliminated after a search of previous work. In other words, records should be carefully scrutinized to see whether anything has been attempted along the line in question. If so, methods and results should be compared and applied to the present problem. If this part of the work is thoroughly and completely done, the result should indicate specifically the point at which the present work should start.

Procedure and Equipment. After the above steps are completed, one is ready to begin operations. A theoretical layout should be made of the machine, if it is a piece of equipment to be made, or of the necessary apparatus if the search is for some fundamental principle. Many obstacles should be overcome in the designing. However, few if any, are able to perfect a design entirely on paper. A scale model involving only a small amount of material and labor often gives almost as good experience as the full-sized article. The next step then is to design and construct a preliminary layout. The experience gained thereby will enable one to proceed more intelligently toward the construction of the full-sized unit. This may involve a considerably different line of attack from the original plan and may itself undergo a number of revisions before the experiment is complete.

Tests to show the effectiveness or observations of various factors will follow according to the nature of the project.

Report. A complete description of all apparatus used and calibrations and checks where necessary, together with an analysis of all test data, should then be assembled in the form of a report.

The principal things to be observed in formulating this report include an introduction giving the reasons for undertaking the investigations and showing the authority therefore. A brief but clear statement of the results sought should also be included. Any theories involved should be carefully and accurately expressed.

All apparatus used should be described in detail, and the inter-relationship indicated and calibrations shown. This is quite important not only as it inspires confidence in the results but also because it makes it possible to duplicate or repeat portions of the experiment without going through it in its entirety.

All steps in the conduct of the project should be clearly shown together with a tabulation of the observations made. In this connection it might be well to emphasize the importance of making observations even more complete than seems necessary. Too often the culmination of an experiment shows the need of data that was not forseen. A little time taken in making observations may save much time later on.

The observations should be assembled in a manner that is clearly understood by a person otherwise unfamiliar with the project and the results or conclusions so concisely stated and clearly arranged that a reader can get the benefit of the work of the experimentalist without having to labor through the entire treatise. It might be a good plan to place the conclusions in the introduction so that there might be no question as to their location.

Expressed in outline form then, the method of approach should in general take the following course:

Procedure in Research

I. Statement of Purpose
   A. Exact nature of problem whether it be to develop a new machine, improve one already in existence, or determine some underlying principle to accomplish either of these.

II. Tentative Plan of Procedure (For purpose of securing authority for procedure)

*The author of this paper is a member of the Research Committee of the American Society of Agricultural Engineers. While this paper is a contribution from the Iowa agricultural experiment station, it was prepared at the request of the Research Committee as a part of its program of instruction on methods of research in agricultural engineering.

A. Proposed method of procedure including probable equipment needed, estimated length of time involved, as well as tentative budget.
B. Plan of cooperation assuring the consideration of each phase of the problem by the investigator best qualified to handle it.

III. History
A. Search of records to find what work has already been attempted or accomplished along the same line.
B. Culling over of the literature obtained to collect all which has any bearing on the project at hand.
C. Deductions from the experience of others and a careful application of the same to establish starting point.

IV. Procedure
A. Revised plan of procedure in the light of a careful study of the literature on the subject.
B. Theoretical design of machine wanted or of apparatus needed to carry out the experiment.
C. Assembly of preliminary set-up or building of trial machine.
D. Revision of plan of procedure or design based on "C" above. (C & D may be omitted from some problems and may be repeated in others.)
E. Assembly of final set-up or building of full-sized machine.
F. Operation of set-up together with observations and analysis of test data.

V. Report
A. Introduction
  1. Reasons for undertaking investigation
  2. Authority for procedure
B. A careful statement of the objectives
C. Discussion of theory
D. Apparatus
  1. Complete description
  2. Arrangement
  3. Calibrations
  4. Runs and observations
  5. Calculations and tabulation
E. Summary and Conclusions

Practical application of principles of approach. In order to make this treatment specific let us make an application in the case of a project on the air requirements of poultry which is being undertaken by the Iowa agricultural experiment station at the present time.*

Object. In this project we find on anaysis that the objects are as follows:

A. To establish standard optimum values of the various factors which are affected by ventilation and which probably influence the general health and comfort of poultry.
  1. Air supply
  2. Purity of air of which CO_2 content is an indicator
  3. Relative humidity
  4. Temperature
  5. Drafts or exposure
B. To determine the quantity of air necessary under various atmospheric conditions in order to provide the best combination of the above factors in poultry houses.
C. To design a ventilating system by means of which the foregoing can be maintained in poultry houses within practical limits of the first cost and maintenance.

The inference is that at least in the minds of the investigators the above information is not only of vital importance but also unobtainable at the present time.

Having the problem thus definitely in mind, we are now in a position to develop to bibliography and make a study of the work of other investigators.

History and Starting Point

In looking up a history of the work done by others we find that the ventilation problem is an age-old question. While but a small amount has been done on poultry, at least a portion of that on farm animals and some on humans is of sufficient importance to demand our consideration.

The value of ventilation has long been recognized. Its exact function, however, as well as the real cause of damage due to improper ventilation and just what constitutes good ventilation have been matters of controversy of long standing. The classic example of effects of bad ventilation is still the episode of the black hole of Calcutta. Almost equally famous is the instance of the Londerry in 1848.

The theories which have been advanced may be grouped under three main heads according to whether the emphasis is laid, respectively, upon the harmful action of carbon dioxide, the presence of toxic organic compounds, or the influence of atmospheric temperature and humidity.

Mayow, as early as the seventeenth century, gave us our fundamental conception of an assumed toxic effect of carbon dioxide. It is interesting to note that there have never been a considerable number of scientific workers who have attributed the harmful effects of poor ventilation to a deficiency of oxygen. Mayow states "If a small animal and a lighted candle be shut up in the same vessel, the entrance into which of air from without be prevented, you will see in a short time the candle go out; nor will the animal long survive its funeral torch.... Nor is it to be supposed that the animal in such a case is suffocated by the smoke of the candle, since if the flame be supplied by the burning spirits of wind, no smoke is produced and yet the animal dies. Moreover, when a candle is used the animal lives for sometime (but not much more than half the time it otherwise would without the candle) after the candle has gone out and its smoke disappeared... Air in which an animal is suffocated is diminished in volume more than twice as much as that in which a candle goes out."

The New York Commission on Ventilation in its report gave a quite detailed summary of the various views held from time to time as to the cause of the harmful effects of a lack of ventilation. After duly considering these and after extensive tests of school room ventilation, they have concluded that temperature, air movement and relative humidity are the most important factors in the ventilation of public buildings. Below are a few extracts from their conclusions:

"In most of the reactions studied in our experiments the effects of chemical vitiation of the atmosphere appeared to be absolutely nil. Temperature and humidity being the same, we compared fresh air containing 5 to 11 parts per 10,000 of carbon dioxide with vitiated air containing 23 to 66 parts and found no difference in body temperature, heart rate, blood pressure, Crampton index, rate of respiration, dead space in lungs, acidosis of the blood, respiratory quotient, rate of heat production, rate of digestion, and protein metabolism."

"Comfort votes indicated that the subjects were quite unable to distinguish from the standpoint of sensation between the fresh and stale air conditions; the performance of mental work was quite unaffected by the chemically vitiated atmosphere. In a special series of animal experiments, guinea pigs exposed to strong fecal odors for considerable periods failed to exhibit any increased susceptibility to inoculations with foreign bacteria or to injection of diptheria toxin." They found, however, that with the temperature and humidity the same, the subjects breathing the stale air performed nine per cent less work than those breathing fresh air.

Regarding appetite and growth they found "by demonstration that exposure to strong fecal odors causes a definite restraining influence upon the rate of growth in guinea pigs during but not after the first week of exposure."

Kelley found that the maintenance of a desired temperature involves insulation, tightness of construction, amount of air space to be heated per animal and the desired amount of ventilation or air movement. He states further that a most desirable percentage of moisture has not been found for special types of animal, but suggests that at a temperature of 40° F. (degrees Fahrenheit) there should be about 81 per cent moisture.

T. D. Hinebauch reported tests in the 1896 report (pp. 1618) of the North Dakota agricultural experiment, showing that, when a poultry house was heated, about half as much food was consumed and the egg production was more than doubled. G. H. Stewart and H. Atwood reported tests in West Virginia station Bulletin 60 (pp. 49-66), on floored vs. unfloored houses for poultry, showing that the best results were obtained in the warmer and unfloored pens and the fowls remained in as

*Four sections of the Iowa station are interested in this project, namely, poultry husbandry, chemistry, veterinary physiology and agricultural engineering.

healthy a condition. H. C. Gardner reported experiments in the Montana station report of 1902 (pp. 96-100), indicating that poultry houses may be profitably heated to an average temperature of 45 to 50° F., although little artificial heat was required in a properly constructed house while the sun was shining.

T. R. Robinson and E. J. Russell reported studies in the journal of the Southeast Agricultural College, Wye, 1905, No. 14, pp. 175-196, indicating that poultry houses without floors are not as satisfactory as those with floors, especially during the winter. Birds housed in floorless buildings laid fewer eggs. Apparently neither temperature or air purity caused the difference. The quantity of heat lost by the birds in the floorless houses was greater, however, than in the other houses, and more of their food was consequently required for fuel purposes. This partially contradicts some of the results noted above.

A. G. Gilbert reported comparative tests of warm and cold poultry houses in the Canada Experimental Farms report for 1906 (pp. 257-272), in which the egg production in unheated houses was slightly greater than in heated houses. This is also somewhat in contrast to the results noted above with reference to temperature.

Temperature records of poultry colony houses at Brandon, Manitoba, reported by F. C. Elford, in Canada Experimental Farms report for 1915 (pp. 1101, 1118, 1120-1152), showed that the best results were obtained in a house having a temperature rather low but uniform and dry.

Studies by H. R. Lewis and W. C. Thompson, reported in New Jersey station Bulletin 325, showed that in order to be efficient the average poultry house should be warmer than the outside normal temperature during the winter and cooler than the outside normal temperature during the summer. All of these results indicate that there must be optimum values of and relations between temperature and humidity.

Experiments reported by A. G. Gilbert in the Canada Experimental Farms report for 1902 (pp. 203-216), showed that the chicks from eggs of hens which had voluntarily run in the fresh air during the winter were strong and lived, while the chicks from eggs of hens which were closely confined died. This is considered to warrant the use of fresh air for breeding stock.

Experiments reported by K. J. MacKenzie and E. J. Russell in the journal of the Southeast Agricultural College, Wye. 1904, on the frequency with which chickens breathe, the amount of inspired and respired air, and the amount of carbon dioxide in respired air and in the air of poultry houses of different construction showed that chickens breathe about a pint of air per minute or 1.2 cubic feet per hour. Older birds breathe more each time than younger birds but breathe more slowly. The proportion of carbon dioxide which poultry can endure with impurity was estimated provisionally at nine volumes in 10,000 of air. From this it was calculated that each bird requires at least 40 cubic feet of air per hour if this limit of carbon dioxide is not to be exceeded. The air requirement of a medium fowl weighing about 4.5 pounds seemed to be much the same as that of a larger bird weighing 7.5 pounds.

Experiments By K. J. J. MacKenzie and E. J. Russell in the Transactions of the Highland and Agricultural Society of Scotland, fifth series, volume 20, 1908, pp. 87-100, showed that in the presence of from 6 to 8 parts of carbon dioxide per 10,000 volumes of air, poultry were apparently healthy. Nine volumes of carbon dioxide in 10,000 of air was found to be the maximum amount that a poultry house should contain. This degree of purity would require 40 cubic feet of air per hour for each bird and an allowance of 10 cubic feet of space in a poultry house per bird.

Armsby makes the general statement, as a result of his researches at the Pennsylvania station, that the amount of carbon dioxide produced by animals is approximately proportional to their heat production, so that the rate of ventilation should also be approximately proportional to their heat production in order to maintain any desired standard of purity of air of a shelter. These results as a whole indicate that there is a very definite optimum range of values of air purity and of oxygen required by poultry for their best health and comfort, that there is probably a definite optimum relation between these two ventilation factors.

A study of these and other aritcles listed in the bibliography following this paper leads us to the following rather general conclusions:

1. Results of previous tests are too general and inconclusive as well as contradictory to be used as basic information.

2. There is a definite need for a project on the subject of poultry house ventilation in which all factors are controlled and variables can be isolated.

3. The ventilation of animal shelters is primarily a winter problem and accompanied with relatively low temperatures. Excessive humidities maintain rather that the deficiency prevalent in public buildings. Chickens do not throw off moisture through the skin and hence depend almost entirely upon respiration for the elimination of moisture and the maintaining of a constant body temperature.

4. Comfort is maintained when the heat of normal combustion approximately balances radiation necessary to maintain a fairly constant body temperature. Warmer atmospheric temperatures tend to increase the body temperatures since loss by radiation is insufficient and lower temperatures require greater food consumption or combustion of the bird's reserve in order to maintain body temperatures.

5. Food consumed in maintaining body temperatures will not produce eggs. Hence, extremely low temperatures cut egg production.

6. High temperatures accompanied by excessive humidities cause discomfort, inactivity and loss of appetite and increase susceptibility to bacterial invasion.

7. Air purity as indicated by carbon dioxide content is probably secondary in importance to temperature, humidity and rate of air movement.

A study of the literature shows that there is probably no farm building which is less standardized at the present time than the poultry house. It seems that houses have been constructed according to the individual ideas of the investigator without any particular reference to the hen. The result has been a wide variation in type. Tests have taken the comparative form rather than the absolute form.

The objects then as stated above provided for three distinct steps in the development of this problem. The first is to take the hen into account as a consulting engineer and determine just what are the vital factors in maintaining health, vitality, comfort and egg production. This, of course, demands proper consideration to such other factors as size and weight of eggs and fertility and hatchability.

The second step is to determine, if possible, the practical phase or the quantity of air which will provide this optimum combination under various atmospheric conditions. This is assuming that, for the present time at least, air conditioning machines are not economically feasible for poultry houses and that we are limited to the manipulation of two factors. These factors are insulation of the house to conserve body heat and a natural ventilation system to provide changes of air.

Once these first two steps are taken care of; the third object is largely a matter of engineering design to provide a system which will maintain, within reasonable limits, the optimum conditions.

General Plan. The proper method of procedure for this project will, of course, be more or less tentative since the very nature of the work implies a large number of undetermined factors. Frequent revision may be necessary but careful forethought may save much later on. In considering the present problem, the general plan may be tentatively stated as follows:

A. Equipment
   1. Ten pens of equal size, hermetically sealed
   2. Air intakes and outtakes provided with valves to prevent back drafts
   3. Apparatus for exhausting air in definite quantities from each pen, sufficiently flexibile that the exact quantity can be regulated and that the amount furnished each pen shall vary in a predetermined progression from pen No. 1 to and including pen No. 10
   4. Provision for the following without disturbing air measurement
      a. Introducing food and water
      b. Removing eggs

c. Weighing birds
d. Cleaning litter and dropping boards
e. Taking all observations
f. Trap nesting and pedigreeing eggs

5. Miscellaneous equipment generally found in poultry houses
   a. Roosts
   b. Nests
   c. Feeders
   d. Waterers
   e. Dropping boards
   f. Trap nests
6. Instruments for observing and recording
   a. Temperature
   b. Relative humidity
   c. Weight of birds
   d. Flow of air
   e. CO_2 content of air
7. Electric lights in each pen to provide uniform amount of illumination in all pens
8. Birds
9. Feed

B. Procedure

1. Determination of optimum flow of air per bird under various atmospheric conditions
   a. Arrange pens with similar equipment and conditions in the following respects
      (1) Floor area
      (2) Light
      (3) Exposure
      (4) Feed
      (5) Water
   b. Seal pens and arrange apparatus so that flow of air can be controlled and exhausted at a definite rate from each pen.
   c. Arrange apparatus so that the temperature within the pens can be regulated and automatically maintained within reasonable limits.
   d. Place 10 birds (9 hens and 1 male bird) in each pen. (Particular care must be exercised to secure birds in good health and as nearly uniform as possible in every respect.)
   e. Runs
      (1) Settings
         (a) Quantity of air to be varied so that pen No. 1 gets an amount clearly insufficient and pen No. 10 gets considerably more than is considered necessary on the basis of present information.
         (b) Temperature and relative humidity to vary as follows

(1)	0° F.	60%	Relative	Humidity
(2)	0° "	70%	"	"
(3)	0° "	80%	"	"
(4)	0° "	90%	"	"
(5)	10° "	60%	"	"
(6)	10° "	70%	"	"
(7)	10° "	80%	"	"
(8)	10° "	90%	"	"
(9)	10° "	60%	"	"
(10)	10° "	70%	"	"
(11)	10° "	80%	"	"
(12)	10° "	90%	"	"
(13)	20° "	60%	"	"
(14)	20° "	70%	"	"
(15)	20° "	80%	"	"
(16)	20° "	90%	"	"

      (2) Length
         (a) Shall be determined by conditions encountered
      (3) Observations
         (a) Health and vitality. (Resistance to infection or disease, particularly of a respiratory nature)
         (b) Consumption of feed and water (appetite)
         (c) Temperatures—inside and outside
         (d) CO_2 content of exhausted air
         (e) Egg production, fertility, hatchability and weight
         (f) Light
         (g) Apparent comfort
         (h) Circulation of blood
         (i) Respiration and metobolism
         (j) Activity (physical work)
         (k) Rate of growth
         (l) Weight of feed and droppings
      (4) Number
         (a) The number of runs shall be sufficient to eliminate errors due to individual differences and to observe whether the same conditions maintain under a wide variation of temperature
      (5) Conclusion
         Optimum values for five factors listed under (1)
2. Amount of air under normal atmospheric conditions to secure best combination of above factors within the pen.
   No. 1 above should give various combinations of air supply, relative humidity, and temperature which will produce the best results. While it would probably not be practical to design a ventilating system so delicate in its operations as to produce these conditions through all variations of atmospheric conditions, it is believed that a correlation can be determined which will be within the limits of the practical and still maintain a comfortable condition within the pen. This part, then, consists of a compilation of data secured above to obtain a tangible basis upon which to work in (3) below.
3. Design of ventilating system to provide within practical limits, and at reasonable cost, the foregoing conditions within a poultry house.
   This section of the project will be purely engineering in character and will consist of designing and testing apparatus to produce and maintain the conditions outlined in (2) above in existing types of poultry houses and if necessary modifying these designs to secure better results.

That this experiment will require a special set-up in the way of equipment is at once evident. It is also equally evident that this must be provided for before further procedure is possible. Our first attention then will be to determine what equipment will be necessary for the proper conduct of the experiment. Some of these must be decided rather arbitrarily at least in the beginning. The outline provides for ten pens hermetically sealed. That they be sealed is of course axiomatic if we are going to measure air supply. The number of pens, however, is an entirely different question. The more pens provided the larger the number of observations which can be made at one time and consequently the total time consumed in the execution of the experiment will be shortened. On the other hand, the larger the number of pens, the more will be required both in the construction of the pens themselves and in the way of other equipment such as instruments for providing certain atmospheric conditions and making observations as well as the number of birds necessary to fill them. The latter is not a small problem since the birds must be very carefully standardized and the difficulty increases much more rapidly than the number increases. The number ten was reached after an evaluation of the above factors involved. In like manner all other matters of equipment were considered and established. Once the equipment is provided the actual procedure follows that outlinted, and we again find it necessary to make a number of arbitrary decisions.

Subjects. The first four steps under the determination of the optimum flow of air per bird under various atmospheric conditions are mere details of standardization. The fifth deals with the number of birds and is subject to the same scrutiny as the problem of the number of pens. The hen is a variable quantity and we must not lose sight of the possibility of error due to individual difference. While on the one hand, it would be desirable to have fifty birds in each pen, the cost would be considerable and probably not justified. On the other hand, a small number such as one or two in a pen entails difficulties

not only on account of indeterminate individual differences but also presents serious mechanical problems in dealing with minute quantities of air, feed, etc. Ten was selected as a medium. Ten pens of ten birds each mean that there are a hundred birds involved. Since the atmospheric conditions vary uniformly from one pen to the next the results should also be uniformly variable and if carefully considered in that light will give results commensurate with using a much larger number in each pen.

Runs. The question of runs is naturally indeterminate since it involves the information sought for. Any predetermined settings are simply starting points which are subject to revision as the experiment proceeds. The length of run will be determined by the length of time necessary for tangible differences in the birds to develop.

Observations. The same is in a way true of the observations to be taken. It seems advisable to observe not only all factors which we know to be important but also others which may seem unnecessary in the beginning. To illustrate the consumption of feed and water might seem entirely unnecessary in connection with a venitlation problem. Yet in the ultimate, feed is just as much a financial consideration to the poultryman as the matter of egg production, and if a change in ventilation that produced an increase in egg production should simultaneously cause a corresponding or greater increase in feed consumption the economic situation would be entirely changed. For this reason, the list of observations was made as nearly complete as possible.

Various records of observations will be kept and reports made from time to time. The fourth division of our outline then is regarding the records and reports. The custom of the organization will be the determining factor. In the project at hand it is stated.

Records of Progress. Observations will be taken throughout the life of the experiment and reports made annually. Length of time necessary cannot be predetermined but will probably extend over a period of several years.

Estimate of Cost. (Construction of pens, etc.)

Construction battery of pens each
Ventilating equipment
Miscellaneous instruments
Labor
Photos and incidentals
Service by regular employees

Cooperation. Without doubt, one of the real problems connected with a project is to secure proper cooperation and coordination. Most projects involve definite problems in more than one field of work. Few commercial organizations can afford to support a crops of experimentalists with sufficiently wide preparation and experience to cover the entire field. Educational institutions usually have an advantage in the diversity of their personnel. The question then is one of securing the proper attitude of cooperation and coordination. It is also equally important, however, that the responsibility be centered in one man and not be too widely scattered. In determining the air requirements of poultry, there are clearly problems involved requiring a wide variety of experience. The design and construction of the apparatus is of course an engineering problem. Any work connected with breeding, raising, selecting and feeding of birds should be handled by an experienced poultryman. Chemical analysis require the services of a chemist and matters of health and disease can be handled best by a veterinarian. For this reason this project is cooperative among four sections of the experiment station and the responsibilities have been divided as follows:

Organization.

A. The Agricultural Engineering Section
   1. Shall furnish apparatus for exhausting and measuring air
   2. Shall furnish instruments for making observations of humidity and temperature
   3. Shall share the expense of construction of pens equally with the Poultry Section
   4. Shall design and superintend construction of apparatus
   5. Shall be responsible for maintaining predetermined conditions of ventilation, temperature, humidity and light
   6. Shall make observations
      a. Temperatures (Inside and outside)
      b. Humidity (Inside and outside)
      c. light
      d. Rate of growth

B. Poultry Section
   1. Shall furnish birds
   2. Shall share expense of construction of pens equally with Agricultural Engineering Section
   3. Shall be responsible for establishing proper and uniform feeding and cleaning of houses
   4. Shall make observaitons
      a. Health and vitality
      b. Consumption of food and water (appetite)
      c. Apparent comfort
      d. Activity (physical work)
   5. Shall incubate eggs and make observations of fertility and hatchability

C. Chemistry Section
   1. Shall be responsible for making analyses of the air and such other observations as may arise requiring the services of a chemist
   2. Shall furnish such equipment as is necessary in in carrying out their part of the project

D. The Veterinary Physiology Section shall be responsible for questions relative to the presence and causes of disease

E. All sections concerned agree to carry out their respective duties promptly and carefully and to render such help in the way of advice or actual assistance as is necessary to the successful carrying out of this project.

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(Continued on page 26)

Agricultural Engineering Digest

A review of current literature on agricultural engineering by R. W. Trullinger, specialist in agricultural engineering, Office of Experiment Stations, U. S. Department of Agriculture

The Influence of Hydrogen Ion Concentration on the Dose of Alum and the Mechanism of the Action of Alum in the Clarification of Natural Waters, N. L. Banerji (Indian Jour. Med. Research, 11 (1924), No. 3, pp. 695-718).—Studies are conducted which showed that with other factors, such as suspended matter, size of particles, and concentration of electrolytes remaining constant, the optimum dose of alum for water clarification increases and decreases with the pH, and that total hardness is an important factor in regulating the dose.

The mechanism of the action of aluminum sulphate is divided into two portions due to unhydrolyzed aluminum sulphate and hydrolyzed aluminum sulphate. The positive aluminum ion from the unhydrolyzed portion is the most potent factor in clarification. The dose of alum can be decreased by the preliminary addition of sulphuric acid. This is considered to be very important from the standpoint of economy in water clarification in the case of slow sand filters when the suspended matter in river water is very high.

Milk Houses for California Dairies, H. L. Belton and J. D. Long (California State Circle 286 (1925), pp. 37, figs. 19).—Practical information on the planning and contruction of milk houses for California dairies is presented, together with numerous plans.

Mole Draining by Direct Haulage, T. Close (Jour. Min. Agr. [Great Britain], 32 (1925), No. 4, pp. 303-306, pls. 5).—This is a well-illustrated description of mole drainage by direct haulage in England.

Dynamometer Tests at Potchefstroom, W. S. H. Clehhorne (Union South Africa, Department Agricultural Journal, 10 (1925), No. 8, pp. 224-226, fig. 1).—Data from dynamometer tests of plowing are briefly summarized, resulting in the development of a new method of yoking oxen, which it is thought will result in making the 3-furrow plow a practical implement.

The Adobe Sweet Potato Storage House in Arizona, F. J. Crider and D. W. Albert (Arizona State Bulletin 106 (1925), pp. 393-410, figs. 15).—Practical information on the planning and construction of the adobe sweet potato storage house for use in Arizona is presented, together with information on preparing the storage house for use, harvesting and handling the potatoes, and management of the storage house.

Alcohol Motor Fuel from Molasses.—I. Use of Cane Molasses for Manufacture of Motor Fuel, E. C. Freeland (Industrial and Engineering Chemistry, 17 (1925), No. 6, pp. 615-621).—This paper contains a general discussion of the equipment needed, methods of manufacture, yields and cost data of alcohol and alcohol-ether motor fuels from cane molasses, with special reference to their manufacture on sugar plantations. Reasons for the use of alcohol fuels, methods for chemical control, and the research problems of the industry are also considered.

Apparatus for Soil Volume Determination, B. Frosterus and H. Frauenfelder (Internatl. Rev. Sci. and Prac. Agr. [Rome], n. ser., 3 (1925), No. 1, pp. 100-104, pl. 1).—This apparatus is described and its use demonstrated.

Ventilation for the New Jersey Poultry House, E. R. Gross (New Jersey Stas. Hints to Poultrymen, 13 (1925), No. 12, pp. 4, figs. 5).—Methods for the winter ventilation of New Jersey poultry houses are presented and discussed and apparatus therefor diagrammatically illustrated.

Installation of Electric Soil Scarifiers [trans. title], A Petri (Elektrotech. Ztschr., 46 (1925), No. 12, pp. 405-407, figs. 5).—Descriptions are given of several types of electric soil scarifiers suitable mainly for gardening purposes. Methods of conveying the electrical current by flexible connections to the machine are discussed, and the use of movable overhead trolleys is described.

The Energy Requirement of Agricultural Localities and Its Influence on Power System [trans. title], W. Windel (Elektrotech. Ztschr., 44 (1923), No. 27, pp. 633-636).—Certain statistical estimates are given in connection with the rural transmission schemes which are common in certain parts of Germany, for the purpose of showing how the figures which have been obtained from existing systems can be usefully applied to the needs of the future.

Electric Power in Agriculture, C. D. Whetham (Journal Royal Agricultural Society England, 85 (1924), pp. 246-270).—This is a brief survey of the present status of the development of the subject in England. It is concluded that further progress lies in developing new or already known uses for electric power on farms, and in improving existing generating plants and adapting them to small-scale rural use.

Tests of Indian Timbers in Structural Sizes, L. N. Seaman (Forest Research Inst., Dehra Dun, India, Econ. Branch Proj. 2 (1925), pp. 16, pls. 5).—Standard tests for structural timbers are outlined in detail, which were formulated for the purpose of establishing correct ratios between the strength functions of small, clear specimens and the allowable working stresses in structural members made of Indian timbers.

Clays as Soil Colloids, A. F. Joseph (Soil Science, 20 (1925), No. 1, pp. 89-94).—In a contribution from the Wellcome Tropical Research Laboratories, Khartum, studies are reported in which repeated centrifuging in a super-centrifuge and shaking of clay suspensions showed that practically the whole of a clay fraction may be obtained in the colloid condition. A certain correlation was found between the physical and chemical properties and the chemical composition of clays.

Experiments with Subsoiling, Deep Tilling, and Subsoil Dynamiting, R. S. Smith (Illinois State Bulletin 258 (1925), pp. 154-170, figs. 6).—Data from deep plowing and subsoil dynamiting experiments in Illinois and other states are summarized, indicating that such tillage methods cannot be expected to materially increase crop yields. Subsoiling, deep tilling, and dynamiting experiments conducted on gray silt loam and brown silt loam showed that such methods are not superior to ordinary or medium depth plowing. Soil moisture determinations made during two seasons on variously tilled plats of silt loam soil showed that none of the tillage treatments used increased the downward movement of moisture through the soil.

An Improvement in the Utilization of Wind Power for the Production of Electrical Energy [trans. title], H. Nottelmann (Elektrotech. Ztschr., 46 (1925), No. 11, pp. 365-368, figs. 6).—A new wind power machine for the production of electrical energy is described and illustrated, and data from its operation are included. It is a completely automatic high speed machine, generating 600 kilowatts at an average wind velocity of 6 meters per second (13.4 miles per hour), which is increased to 800 kilowatts at a wind speed of 8 meters per second. The revolution speed of this plant is from 6 to 8 times that of ordinary windmills and wind moats.

Earth Pressure Against Abutment Walls Measured with Soil Pressure Cells, J. V. McNary (U. S. Department Agriculture, Public Roads, 6 (1925), No. 5, pp. 102-106, figs. 8).—Studies are reported from which the conclusion is drawn that the pressure of earth against a retaining wall should not under ordinary conditions be assumed to be less than that which would be developed by a fluid weighing 30 pounds per cubic foot. The tests also indicate the importance of suitable provisions for draining the fill, since it was shown definitely that a direct relation exists between the high pressures measured and a condition of high moisture content.

Preservative Treatment of Fence Posts (Iowa Station Report, 1924, p. 51).—Studies on the treatment of nondurable fence posts with preservatives, which have been under way for from 17 to 18 years, are said to show conclusively that creosoting is a big factor in cutting down fencing costs in Iowa. Cottonwood, willow, and elm fence posts which were given a good creosote treatment 17 or 18 years ago are still in service, and some of these posts give evidence of lasting for a total period of 25 or more years.

Production Methods in a Tractor Plant (Machinery, 32 (1925), No. 1, pp. 32-35, figs. 10).—In a second article on methods used in the manufacture of farm machinery, descriptions are given of some of the more unusual operations performed in tractor manufacture.

Nine Charts for Flow of Water in Channels, G. Higgins (Engin. and Contract., Water Works, 64 (1925), No. 3, pp. 607-613, figs. 9).—Nine charts are presented and discussed, which are based upon Bazin's formula for channels.

The Efficiency of a Short-Type Refrigerator Car, R. G. Hill, W. S. Graham, and R. C. Wright (U. S. Department Agricultural Bulletin 1353 (1925), pp. 28, figs. 11).—Three tests of a short type of refrigerator car are reported which showed that a very heavy load detracts from the efficiency of a car. This type of car will effectively refrigerate a load of 294 or 315 crates of celery. A load of 336 crates placed 8 crates wide and 3 layers high in 14 stacks retards the air circulation within the car, thus preventing efficient refrigeration of the load.

The Toxicity of Petroleums, E. Bateman and C. Henningsen (American Wood Preservers' Association Proceedings, 21 (1925), pp. 57-61).—Studies conducted by the U. S. D. A. Forest Products

Laboratory on the use of petroleums in the preservation of wood are briefly reported.

The results indicate that no petroleums thus far examined can be used alone as wood preservatives in places where fungus attack is severe. It is considered unlikely that any American petroleums can be used alone as wood preservatives, but they may be used as carriers for one or more toxic materials.

Heat Transference and Combustion Tests in Small Domestic Boiler, H. W. Brooks, M. L. Orr, W. M. Myler, Jr., and C. A. Herbert (Journal American Society Heating and Ventilating Engineering, 31 (1925), No. 2, pp. 89-118, figs. 17).—The results of a series of tests by the U. S. Bureau of Mines made with various fuels to determine heat absorption and other characteristics of sectional boiler construction are reported. The primary purposes of these tests were (1) to determine the additional amount of heat absorbed by the addition of three sections over the base and fire pot, (2) to obtain data regarding the passage of free oxygen from the ash pit to the space above the fuel bed, and (3) to ascertain the value of ordinary methods of admitting secondary air over the fuel bed when using hard and soft coal and coke. A large amount of data is presented and discussed, which seems to indicate in general the increased efficiency resulting from the addition of three sections, and the importance of admitting secondary air over the fuel bed when burning bituminous coal.

The More Unusual Gases Occurring in Imhoff Tanks, F. L. Campbell and W. Rudolfs (Engineers News-Record, 95 (1925), No. 14, pp. 552, 553).—Studies conducted by the New Jersey experiment stations and the New Jersey state department of health on the occurrence of the unusual gases of hydrogen and hydrogen sulphide in Imhoff tanks are briefly reported.

At least fifty analyses from Imhoff tanks which were not functioning properly, extending over a period of two years, failed to reveal the presence of hydrogen in the gas from any tank at any time. This is taken to indicate that hydrogen does not appear as the result of every disturbance in tank operation. Hydrogen was found to be absorbed by sludge, but it was not made clear whether or not the disappearance of hydrogen in sludge was due to chemical combination, absorption, or the catalytic action of living organisms. Hydrogen sulphide was found in the gas from a new tank.

Algal growths in Tank Waters and the Effect on Them of the Removal of the Dissolved Bicarbonates of the Water by the Addition of Sulphuric Acid, V. G. Raju (Indian Jour. Med. Research, 11 (1924), No. 4, pp. 1057-1063).—It is stated that many of the tank waters in Bengal are rendered unfit for drinking by the growth and subsequent decay of algae. The chief causes of their presence are the accumuation of algal spores and resistant forms in the debris at the bottom and sides of the tank, the presence of bicarbonates in the tank water, a certain amount of quiescence and transparency in the water, and a suitable atmospheric temperature. Their death and decay are brought about chiefly by the high temperature prevailing in summer.

It has been found that a thorough removal of the soil from the sides and bottom of tanks gets rid of algal spores and material serving as their food. The entire removal of the bicarbonates present in the water by the addition of sulphuric acid is also a medical measure.

The Improved Venturi Flume, R. L. Parshall (American Society Civil Engineering Proceedings, 51 (1925), No. 7, [pt. 3], pp. 1340-1349, figs. 4).—In a contribution from the Colorado experiment station and the U. S. Department Agriculture Bureau of Public Roads, a device is described for measuring the rate of flow of either small or large quantities of water. It has no moving parts, is simple and inexpensive, utilizes the principle of a hydraulic control, and sacrifices little head. The improvements over the old Venturi flume consist in the reduction of the convergence in the inlet section, lengthening of the throat section, change of divergence of the outlet section, and depressing the floor in the throat section. These changes have been found to improve the flow conditions, reduce the effect of submergence, and simplify the operation by reducing the number of gauges necessary to determine the discharge. Tests are reported which indicate an accuracy of about 5 per cent.

Earth Structure Mechanics from the Soil Physics Standpoint, K. Terzaghi (Erdbaumechanik auf Bodenphysikalischer Grundlage. Leipzig and Vienna: Franz Deuticke, 1925, pp. XV + 399, pl. 1, figs. 64).—This is a manual of soil physics and mechanics with particular reference to their engineering applications. It contains chapters on soil properties, soil friction, tenacity of soils, hydrodynamic tension phenomena, soil statics, and soil as a structural material. A large amount of tabular and graphic data is included.

Plows and Plowing.—II, A study of Some Typical Filipino Native Plows, A. L. Teodoro (Philippine Agr., 14 1925), No. 3, pp. 135-142, pl. 1, figs. 2).—A description is given of the mechanism and construction of the various parts of different native plows, and the action of these parts is briefly analyzed with reference to quality of work and of draft in the act of plowing. While the implements investigated are apparently quite primitive, it is stated that native farmers find them to be very simple in construction, very light, and easy to manipulate. They can also be used conveniently to plow out corners of small fields. The general purpose plow is designed to break up the surface of the soil in first plowing rather than to pulverize it, and it is necessary to plow at least twice before a mellow seedbed can be produced. All the parts composing the plow, aside from the moldboard and share, are made of wood, which presents the advantage that the wooden parts either break or spring back to their original positions when subjected to stress.

Influence of Defective Electric Installations on Fire Safety, Especially in Agriculture [trans. title], K. Schneidermann (Elektrotech. Ztschr., 44 (1923), No. 16, pp. 353-358, figs. 20).—Descriptions are given of a number of instances of poor construction and materials and defective installation of electrical equipment in farm buildings in Germany which have resulted in fires.

A strong objection is raised to the practice of leading wires through the interior of farm buildings, from barn to stable, and through hay lofts and root stores. Cases are cited of the destruction of iron conduits and cable insulation by the ammoniacal vapors from stalls and pig sties.

It is concluded that all cables, switches, fuses, branch boxes, and motors should be outside of the main farm buildings, in locked boxes or rooms with the opening for shafts or belts from motors made as small as possible or provided with covers to be closed when not in use. The wiring to the lamps should be led in through the side walls as directly as possible and not through the roof.

Oil Flow in Complete Journal Bearings, D. P. Barnard, IV (Journal Society Automotive Engineering, 17 (1925), No. 2, pp. 205-209, figs. 9).—General laws governing the rate of flow of oil through complete journal bearings are developed, which are based on the assumption that axial flow is a function of the bearing load. It is shown that a complete journal bearing can be considered as an oil pump, in which the pressure developed is utilized to support the imposed load and to induce a flow of oil through the bearing. The volumetric efficiency of a bearing as a pump is a function of the factors governing bearing operation, grouped in the dimensionless order viscosity times rubbing speed divided by bearing load, length divided by clearance, and length divided by diameter. The first of these apparently exerts a predominating influence.

Oil feed pressure was found to increase the total flow through a bearing by an amount proportional to the feed pressure. The rate of heat generation increases approximately as the square of the speed and oil flow as some power less than the first. Unless heat dissipation by metallic conduction is very efficient, the temperature rise in a bearing will increase at a rate greater than the first power of the speed.

Water Power and Flood Control of Colorado River Below Green River, Utah, E. C. La Rue (U. S. Geological Survey, Water-Supply Paper 556 (1925), pp. X + 176, pls. 79, fig. 1).—The purpose of this report, which contains a foreward by H. Work, is to present the facts regarding available water supply and all known dam sites on the Colorado River between Cataract Canyon, Utah, and Parker, Arizona, and to show the relative value of these dam sites. For the latter purpose a comprehensive plan of development for the Colorado River below the mouth of Green River is presented, which will provide for the maximum practicable utilizaiton of the potential power, maximum preservation of water for irrigation, effective elimination of the flood menace, and an adequate solution of the silt problem. This plan contemplates the construction of thirteen dams, making available 3,383 feet of head for the development of power and a maximum of 42,000,000 acre-feet of storage capacity for the control of floods, equalization of flow, and storage of silt. Under the plan suggested and with the water supply estimated to be available in 1922, 4,350,000 continuous horse-power may be developed.

A Method of Research as Applied to a Project on the Air Requirements of Poultry

(Continued from page 24)

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A. S. A. E. and Allied Activities

Annual Meeting of North Atlantic Section

THE North Atlantic Section of the American Society of Agricultural Engineers met at Schenectady, New York, December 10, 11 and 12. A three-day program which carried well into two evenings was well attended, the total registration being eighty. The meeting was called to order by Chairman R. U. Blasingame, who welcomed the assembly of engineers and introduced the first speaker, F. A. Wirt, president of the Society.

Mr. Wirt in his address entitled "The Responsibilities and Opportunities of Agricultural Engineers," stressed the economic problems of agriculture. In tracing the growth of the farm machine industry for the past one hundred years Mr. Wirt said that "if the 697,000,000-bushel wheat crop of the United States for 1925 was grown and harvested by the farming methods of 1849 a force of workers equivalent to the entire population of the United States, plus 26,000,000 others, would be required." The revolutionizing of farming through the use of modern farm machinery was graphically illustrated showing that the farmer of today must face two alternatives, one being to decrease the cost of production and the other to increase the sale price. As the individual farmer largely controls his production costs, it is evident that here lies the most fertile field for increase of profit.

A paper entitled "Agricultural Economic Problems" was presented by B. B. Robb, professor of agricultural engineering, Cornell University, in which he pointed out the relation between costs of farm structures and land values. A most serious problem confronts the farmer in replacing structures originally built at a comparatively low cost both for labor and materials. These buildings were the product of farm labor, largely, the material being grown on the farm and only a small amount of outside labor needed. Today many of these buildings are unsuitable from the standpoint of sanitation, arrangement, or changed conditions of farming. Professor Robb brought out that, if a farmer were to purchase farm buildings at somewhere near their real value, the owner would be willing in most cases to throw in the land for nothing. He also said it would seem certain that the economist and the engineer might do well to work jointly on these farm problems of today.

E. K. Hibshman, assistant to the president of Pennsylvania State College, discussed the organization of land-grant colleges endowed by the Morrill Act of 1862, giving 30,000 acres of public lands, the proceeds of which are used to meet the educational needs of the agricultural and mechanic arts. The Hatch and Adams Acts, together with the Purnell Bill, gives each state about ninety thousand dollars annually for research work. The Smith-Lever Act of 1914, which appropriates and distributes federal money on the basis of rural population, provides for directors of extension and county agents, as well as other extension specialists.

R. W. Trullinger, agricultural engineering specialist of the U.S.D.A., Office of Experiment Stations, delivered an address on the subject "National Agricultural Engineering Research." Attention was drawn to the fact that much fundamental research of a broadly applicable nature is needed before any advance can be made in the design of many types of farm machinery, farm structure and farm equipment. The importance of knowing the exact requirements which such equipment should meet should be fully known before economical and satisfactory designs can be developed. A national program of research in farm equipment should, therefore, be based upon the collective requirements from the different states themselves.

The relation of agricultural and engineering departments of the state college to the agricultural industry was the subject of a paper presented by Prof. S. E. Seitz of Virginia Polytechnic Institute. The importance of close cooperation by agricultural engineers with the branches of agricultural science was stressed.

The entire evening session of December 10 was devoted to rural electrification. The subject was ably handled by H. W. Riley, professor of agricultural engineering of Cornell University, who spoke on the subject from the viewpoint of the agricultural college. Prof. Riley pointed out that the colleges are interested in stimulating activities that will improve living conditions for the farmer, rural electric service being one of the most important of these activities.

C. H. Churchill, of the Adirondack Light and Power Company, presented a paper on the subject from the viewpoint of the power company, in which he stated that the present policy of power companies is to follow up line construction with tests and experiments on the farm and to cooperate with electrical and farm machinery manufacturers to the end that electric service may be of more value to the farmer, for it is recognized that farm lines will be good business for the power companies only when electric service can be shown to be good business for the farmer.

W. T. Ackerman, of the University of New Hampshire, spoke on the same subject from the viewpoint of the experimental rural electrification project.

A. D. Bell, lighting engineer of the Edison Lamp Works of General Electric Company, presented a paper dealing with the characteristics of good lighting practice as applied to the farm. This included both the farmhouse and the outbuildings. Mr. Bell brought out that this is only obtained by the use of the proper type and size of incandescent Mazda lamps in connection with suitable reflecting equipment. The lamp itself provides the light while the reflector directs and disposes it thus transforming raw light into adequate illumination.

Attention was drawn to the advisability of providing sufficient circuits in the initial installation to allow for expansion in the form of additional lights and convenience outlets to which utility appliances might be connected.

The program on December 11 was opened by F. J. Bullock, vice-president of the Papec Machine Company. Mr. Bullock in a paper discussed belt speeds and drives and proposed the adoption of a standard belt speed for all tractors. About ninety per cent of all tractors built in the United States during the past year he said, were designated for belt speed of from 2500 to 2800 feet per minute.

L. G. Heimpel, professor of agricultural engineering of McDonald College of Quebec, presented a paper on the dilution of crankcase oil in kerosene-burning tractors. This paper dealt mainly with the increased dilution of crankcase oils with the coming of the less volitile fuels. The farmer wants the cheap fuel as long as there is a difference of several cents a gallon, but his big problem is the maintenance of successful and economical lubrication with the lower grade fuels.

The farm building situation was discussed by N. S. Grubbs, of the Portland Cement Association. Mr. Grubbs called attention to the constantly and rapidly changing conditions under which our farm buildings are being constructed, due to increased costs of building materials formerly used, to problems of farm sanitation, to better knowledge of storage conditions, and to necessity for disease control. An increase of approximately fifteen per cent in the valuation of farm buildings has taken place since the census of 1920.

Prof. E. R. Gross of Rutgers University emphasized by recent statistics the statements made by Mr. Grubbs and said that in many of the eastern states valuations of farm buildings now exceeded valuation of farm land alone, and he predicted that the present decade would show a still further increase. Mr. Gross states that due to improved economic conditions the farmers are again investing in equipment, a goodly portion of which is in buildings.

John R. Haswell, of Pennsylvania State College, in a paper on farm sanitation problems, discussed the water supply problems on the farm. A recent survey of home conveniences in

the state of Pennsylvania showed that about twenty-five per cent of the farm homes had running water in them.

Ventilation for livestock was discussed by O. B. Stichter of the Louden Machinery Company. He discussed the effects of poor ventilation on cattle in the northern states during the winter months from the standpoint of loss of health to the cattle and a monetary loss to the farmer. He discussed various forms of ventilation in cattle barns, and also gave valuable information concerning properly constructed buildings and properly installed ventilation systems.

Gayne T. K. Norton, publicity director of the Save-the-Surface Campaign, Philadelphia, in his paper on paints and varnishes for farm buildings, emphasized the great need of paint on farm buildings in order to lessen the depreciation and increase or strengthen the morale of the owner.

The entire afternoon of December 11 was taken up with a trip through the General Electric Company's plant. The shops of several different departments were visited, and at the close a trip through the broadcasting station WGY was arranged.

An elaborate banquet in the evening with Prof. H. W. Riley as toastmaster was greatly enjoyed. The big feature of this banquet was arranged by C. T. McLaughlin of the General Electric Company. Red tablecloths, red napkins, castors, celery holders, cake standards, strawhats, and overalls were in order. Mr. McLaughlin arranged to have some excellent G. E. Slight-of-hand performers, magicians, singers, and bell ringers present at the banquet.

The first annual business meeting of the North Atlantic Section was held during the forenoon of December 12 and reports of all officers and committees were made. Election of officers for the ensuing year followed. R. T. Wagner, General Electric Co., was elected chairman; C. E. Seitz, Virginia Polytechnic Institute, vice-chairman, and W. C. Harrington, secretary. It was voted to accept the invitation of Pennsylvania State College to hold the next annual meeting there.

The Better Farm Homes Conference

DURING the recent years agricultural engineers have given a great deal of attention to farm home needs. Studies of farm home requirements from an engineering point of view have been undertaken for the purpose of making the home more efficient, eliminating drudgery, and making available to the farm family improved methods, equipment and materials that tend to raise the standard of farm living to a level with the best in point of comfort, convenience, health, and pleasure.

In line with this effort and appreciating the need for still more intensive as well as more extensive effort, the American Society of Agricultural Engineers, under the auspices of its Farm Structures Division, will hold a Better Farm Homes Conference at the Hotel Sherman, Chicago, Illinois, February 18 and 19, 1926. The purpose of this conference is to bring together all agencies interested in the better farm homes movement for a better understanding of the problems involved and to give greater impetus to the movement by formulating ways and means by which continuity of effort and coordination of activities can be developed.

An invitation to attend the Conference and take part in the discussions is extended by the Society to all persons and agencies interested in bringing about a higher standard of living on the farm. National organizatons of a civic nature, as well as those representing manufacturers of materials, equipment, etc.; divisions of agricultural engineering and home economics of public educational institutions; allied manufacturers, etc.—all are urged to have representatives attend the conference and participate in the discussions.

A program for the Conference is being developed that will take up the better farm homes subject from various angles. Speakers of national reputation and prominence are being secured. They include agricultural engineers who have given extensive thought and study to improvement of the farm home, specialists in farm home economics, and last, but not least, a farm woman who has spent several years making a careful study of ways and means by which the drudgery of her own household duties could be lightened and life in her home made more comfortable and pleasant.

A.S.A.E. Organization, 1925-26

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Committee on Better Farm Homes—W. D. Brinckloe, chairman, Easton, Md.

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Committee on Portable Motors—E. W. Pilgrim, chairman General Electric Co., Schenectady, N. Y.

Committee on Methods of Motor Drive—D. L. Renner, chairman, Westinghouse Electric and Mfg. Co., East Pittsburg, Pa.

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223 Husband Street, Stillwater, Okla.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publicaiton of the December issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Albert Henry Bates, superintendent of tractor department and works engineer, Emerson-Brantingham Co., Rockford, Illinois.

Albert Reynolds Beal, sales promotion manager, Central Hudson System of Gas and Electric Companies, Poughkeepsie, New York.

Wilber Fisk Crane, planning barn construction and selling barn equipment, Palmyra, New Jersey.

William J. Fox, Fulton County Gas & Electric Co., Cobleskill, New York.

Howard Charles Fuller, agricultural engineer, Utica Gas & Electric Co., Utica, New York.

Thomas D. Harman, general manager, Stockman-Farmer Publishing Co., Pittsburgh, Pennsylvania.

O. W. Johnson, president, Ward-Love Pump Corporation, Rockford, Illinois.

George Frederick Krogh, technical draftsman, University of Minnesota, St. Paul, Minnesota.

Ralph B. Lourie, vice-president, John Deere Plow Company, Moline, Illinois.

W. C. McWhinney, general business agent, Southern California Edison Company, Los Angeles, California.

James McVicar Mills, Jr., ranch manager, S. Mills Orchard Corporation, Hamilton, California.

Wilbur K. Moffett, manager, agricultural bureau, State Chamber of Commerce, Harrisburg, Pennsylvania.

Frank D. Paine, professor of electrical engineering, Iowa State College, Ames, Iowa.

Earnest W. Pilgrim, industrial department, General Electric Company, Schenectady, New York.

George Edward Simmons, professor of agronomy and head of department of agronomy and agricultural engineering, University of Main, Orono, Maine.

Charles A. Utley, field engineer, The Pelton Water Wheel Co., San Francisco, California.

Hibbert M. Weathers, in charge of rural electric development, Alabama Power Company, Birmingham, Alabama.

Andrew Weiss, assistant director of reclamation economics, Bureau of Reclamation, Department of the Interior, Denver, Colorado.

Transfer of Grade

Wesley G. Nunn, instructor in agricultural engineering, Virginia Polytechnic Institute, Blacksburg, Virginia. (From Student to Junior Member.)

Employment Bulletin

This service, conducted by the American Society of Agricultural Engineers, appears regularly in each issue of Agricultural Engineering. Members of the Society in good standing will be listed in the published notices of the "Men Available" section. Non-members as well as members, are privileged to use the "Positions Available" section. Copy for notices should be in the Secretary's hands by the 20th of the month preceding date of issue. The form of notice should be such that the initial words indicate the classification. No charge will be made for this service.

Men Available

AGRICULTURAL ENGINEER open for position as sales engineer, salesman, advertising writer, or agricultural propagandist. Past experience with large agricultural firms. MA-124.

AGRICULTURAL ENGINEER, 1924 graduate of Kansas State Agricultural College, with farm experience, would like permanent employment at once, preferably with a farm-machinery manufacturer. MA-126.

AGRICULTURAL ENGINEER, 1925 graduate of College of Agriculture, at the University of Illinois, who has specialized in tractors and farm-power machinery and lubrication, and who has had eight years' experience in the operation, repair, and demonstrating of tractors and related farm machinery, desires a position preferably with a farm-machinery manufacturer or oil company. MA-127.

Positions Open

AGRICULTURAL ENGINEER to teach farm buildings, agricultural drawing, rural architecture, and to handle the extension work in farm buildings is needed at Virginia Polytechnic Institute, Blacksburg, Virginia. The work is so arranged that one-half time will be devoted to resident instruction and the other half to extension work. Most of the extension work at present is confined to actual designing of farm structures with some field work. A man is wanted who is capable of developing the extension phase of the work to the highest efficiency. Those interested should write C. E. Seitz, head of the department of agricultural engineering.

SALES ENGINEERS WANTED: One of the largest bearing manufacturers in America can use the services of two good sales engineers. Men with an engineering education and sales experience in farm tractor and implement field are preferred. They should have designing ability so that they can be of service to customers. Those experienced in the farm-implement and tractor design will be shown preference. Write fully giving all data as to experience, education and salary expected.

ENGINEER wanted, by one of the largest farm-machinery manufacturers, who is alive to the real engineering possibilities incidental to the manufacture of farm machinery, whose theoretical engineering training is complemented by a few years work at the drawing board in some engineering department and who will at once know the significance of routine efforts necessary to the accomplishment of any job in a production shop and be in position to appreciate the shop man's viewpoint. PO-111

EXTENSION AGRICULTURAL ENGINEER qualified to handle farm machinery and gas engine schools in various communities in the state, and also qualified to handle other lines of agricultural-engineering activity which an extension man is called upon to perform is wanted by the University of Nebraska. Candidates for this position should write O. W. Sjogren, chairman, department of agricultural engineering, Lincoln, Nebraska.